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ILLINOIS TECHNOGRAPH

DECEMBER 1954

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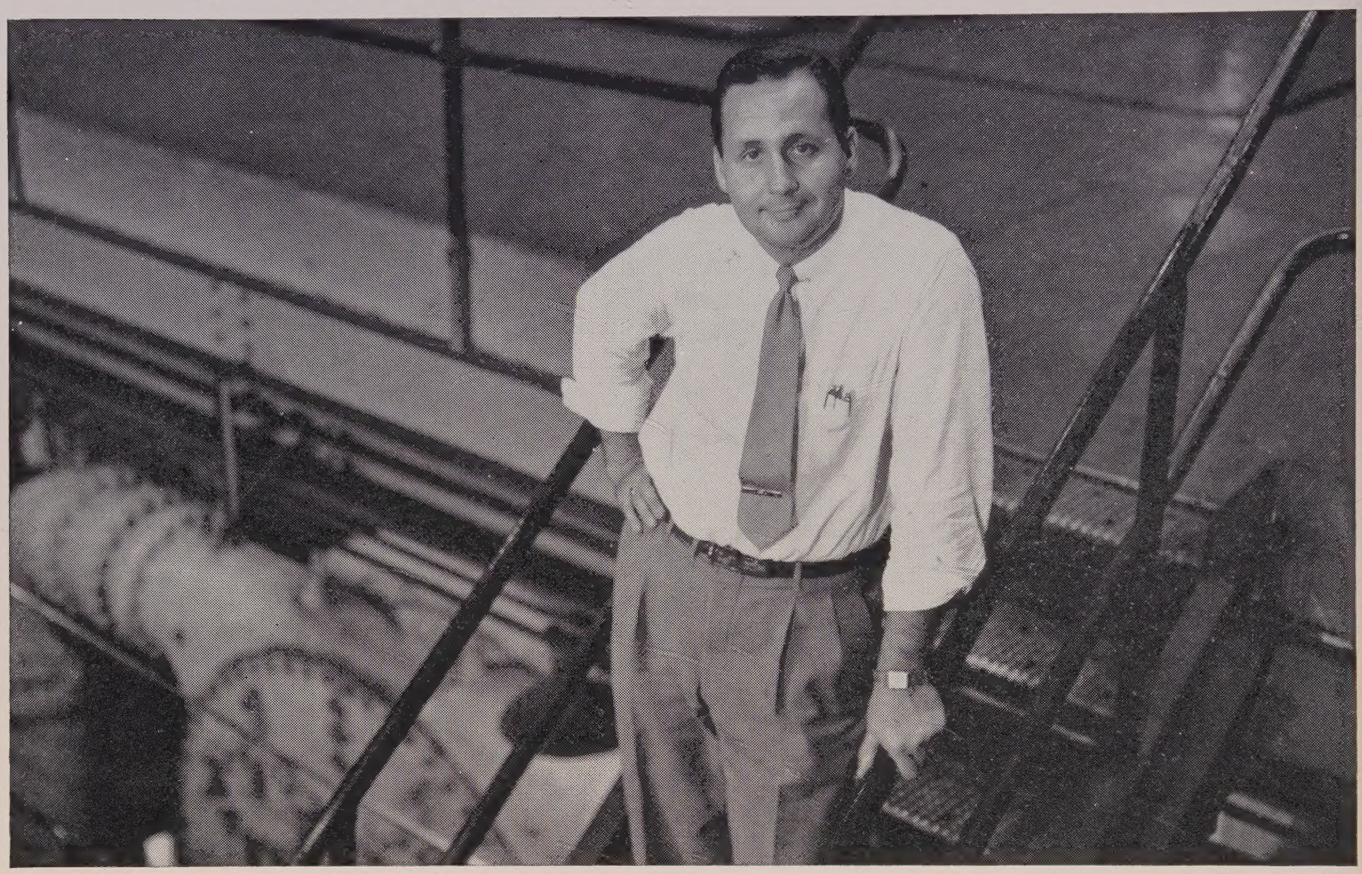
Robert L. Schneider, class of '49, speaks from experience when he says . . .

"United States Steel offers unlimited opportunities covering practically all engineering fields"



IN 1949 Robert L. Schneider graduated from college with degrees in engineering and physics. After being interviewed by United States Steel, he was accepted as a trainee. Then after a year, he was advanced to a test engineer in the Maintenance Department; then to a power foreman in the Power & Fuel Division. By 1953, he had been made Power Superintendent in the Power & Fuel Division at the Carrie Furnaces.

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THE ILLINOIS TECHNOGRAPH

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contents:

system sand control ---------- 9

automotive gas turbines ---------- 11

the use of slots and the boundary layer fence ---------- 14

illini rocket inquiry ---------- 21

the bench molding process ---------- 24

new method simplifies welding ---------- 26

recognized minimum standards ---------- 28

recommended minimum standard ---------- 29

introducing ---------- 33

skimming industrial headlines ---------- 34

theory versus practice ---------- 43

technocracks ---------- 48

our cover

The entrance of Bevier Hall. Women's physical education courses, mixed dancing classes and swimming classes are taught here. Home Economics headquarters is also located in Bevier Hall.

our frontispiece

This picture of a cupola was taken in the Foundry Lab at the University of Illinois. At the end of each heat the bottom doors on the cupola are opened to remove the remaining contents of the cupola.

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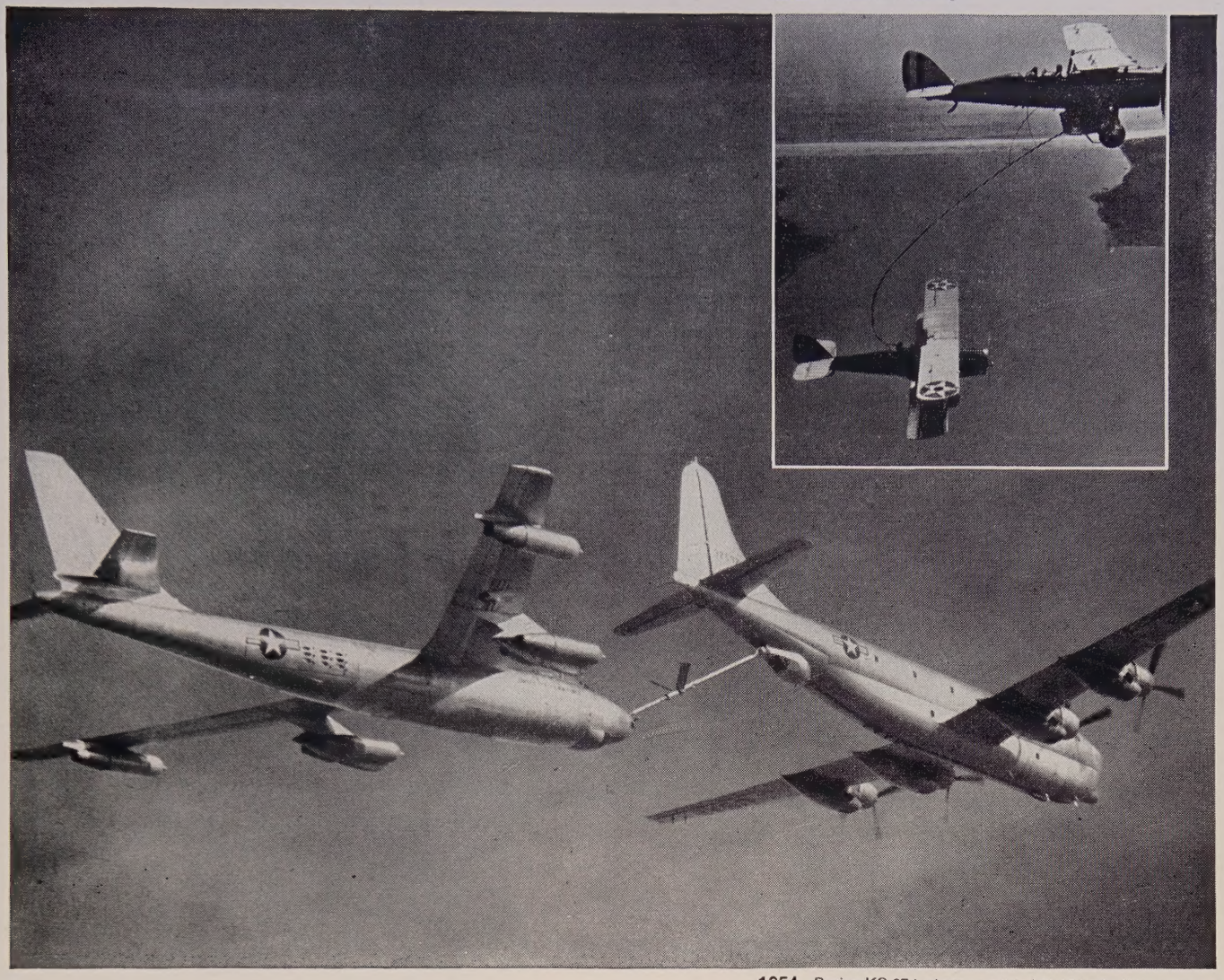
1923—first aerial refueling

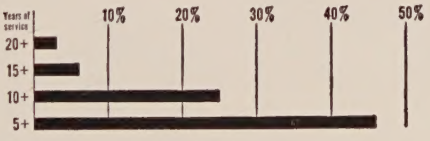


1954—Boeing KC-97 tankers completed 16,000 refuelings last year

30 years of progress in aerial refueling

The small picture shows the first aerial refueling by the Air Force. The large picture shows a Boeing KC-97, today's standard Air Force tanker, transferring 600 gallons of fuel a minute to a Boeing B-47 Stratojet bomber.

Boeing pioneered aerial refueling tankers and equipment. Further, during its 38 years, it has constantly pioneered trend-setting designs in commercial and military aircraft. This has meant such continuous growth that Boeing now employs more engineers than ever before, including the World War II peak. Boeing offers *stable* careers to engineers of virtually EVERY type: civil, mechanical, electrical and aeronautical. The company employs draftsmen and engineering aides for routine work, thus freeing engineers for more creative assignments.



Boeing engineers enjoy long-range careers—46% of them have been at Boeing 5 or more years, 25% have been here 10 years, and 6% for 15 years.

In addition to stability, Boeing offers an unusual variety of research, design and production opportunities, including work with new materials, guided missiles, jet bombers and transports, and research in nuclear-powered aircraft and supersonic flight.

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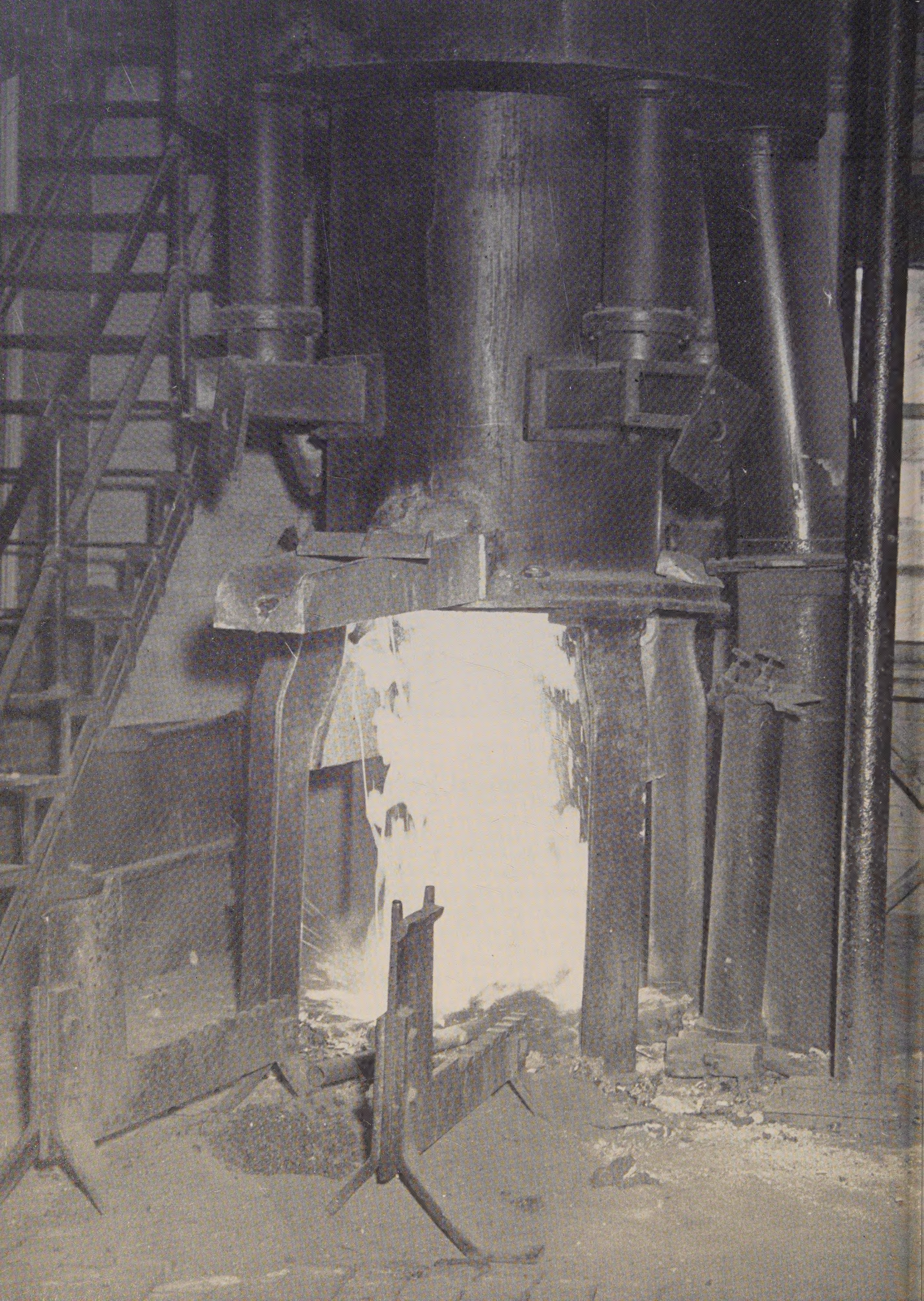


SYSTEM SAND CONTROL

by Norman E. Goelzer, M. E. '56

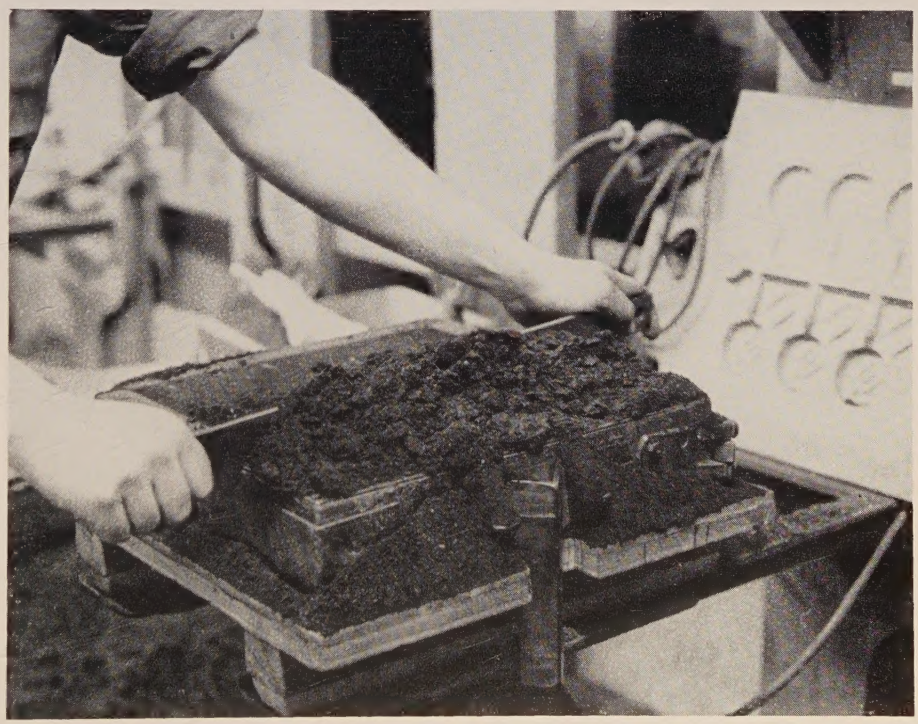
Sand control is as important to foundries as proper mechanization, especially to the Pacific Cast Iron Pipe and Fitting Company whose location necessitates large expenditures for Nevada sand. Their freight costs for these eastern silicon sands may run twice the price of the sand, itself. Along with sand control, the control of other parts of the system is necessary. Their system for complete control of production is based on the control of the component parts of the system and consists of core sand control, molding sand control, and equipment control. Also an extensive testing program and an inspection department help coordinate the component parts of the system. All the individual control processes help produce an efficient production with only a small per cent loss of castings.

The first important component of control starts in the core room. Two reasons for core room control are the sand from the cores becomes mixed with the molding sand, and good core room practice produces a high quality of castings. Therefore, core sand which will become molding sand should be of correct A.F.S. fineness and grain distribution to properly function as a molding sand. Actually, the sand is a molding sand that will work as a synthetic core sand. Other requirements for a molding sand to work successfully as a core sand are workability, sturdiness, porosity, and economy. The necessity for having the proper amount of core sand is important to constant control, since the addition of sand to balance the loss of molding sand causes irratic control. Still other factors that enter into cores are factors which pretains to core room practice. These are:[1]

1. Screen and measure (by weight or volume) all sands.
2. Keep core room equipment accurate and in good operating condition.
3. Make routine screen analysis tests to check the uniformity of the grain fineness and distribution of incoming sand.
4. Use the simplest mixture that will develop a core with adequate properties under controlled mixing conditions.

A (30-50 A.F.S. fineness) screen sand is used by the Pacific Cast Iron Pipe and Fitting Company as a compromise between the common sand used for cores and molding sand. For such a sand contains the desirable properties of flowability, lower oil consumption, and ease of venting.

The next important component part is control of the molding sand. The first important item is to have a large enough supply of sand to eliminate using hot sand (temperature above 110 degrees Fahrenheit) which will cause excessive moisture loss, stickiness, and poor workability. This requires a large storage space to carry on high production. The Pacific Cast Iron Pipe and Fitting Company have two fifty-ton storage bins to take care of the 1,400 lbs. of sand that are used every three minutes. The sand from the shake-out is stored in the bins where it is allowed to cool before going to the mullers. In the mullers the sand is mixed with one and three quarter pounds of western bentonite, one and three quarter pounds of southern bentonite, one pound of proprietory facing material, and the proper amount of wat-



Excess sand is struck off with a straightedge called a strike-off. The mold is then rented by being perforated with a rent wire. (Photo by Al Shiner)

er. These additives give the sand the following properties:[1]

	Mullers	*Hoppers*
Permeability Green	55-65	69-70
Compression, psi	9.0-11.0	10.0-12.0
Moisture, %	4.2-4.5	3.9-4.1
Hardness	82-86	85-90
Dry Shear, psi	25.0-30.0	20.0-25.0

These ingredients produce jolting, squeezing, raming, peen raming ability. Also the ability of the sand to retain the desired shape during handling, molding and moving. The sand system should be designed to help maintain these physical properties and uniform grain distribution. For an economical and efficient production the system should also be designed with simplicity, adequacy, and economy in mind.

Control of machinery and economical planning of the machinery used in the foundry are necessary for efficient production. Economical planning is necessary to eliminate over-mechanization which can cause financial loss, and it consists of determining whether certain equipment is desirable. This should be determined by first considering whether available equipment and facilities can be used with various modifications to eliminate the purchase of new equipment. The sand to metal ratio furnishes information to the efficiency of the foundry system. This can be calculated by dividing the weight of the sand by the weight of the metal poured minus the spures, gates, and the feeders. If the available equipment will not function efficiently then new equipment should be purchased.

The control of machinery is also very important. If one machine doesn't function propertly the efficiency of the whole system is impared for one part of the system will affect the rest of the system. Some examples of improper operation of the system are the following: a conveyor running to fast causing the molds to crack or to drop sand into the mold cavity, piping of the sand in the storage bin, plugged pipes on the dust collectors, missing or loose buckets on the elevators, to light or to severe a shake-out, muller plows set to high, poor hopper design, and slippage in the belt conveyors. To eliminate the various losses due to malfunctioning machinery rigid inspection and maintenance should be carried on at regular intervals. For example the items to be considered for a belt conveyor are:[1]

1. It should move at a rate that is within the specified range recommended by the manufacturer or designer.
2. Within the framework or adequate molding practice, it should not hold back full production.
3. The conveyor should move at a rate that will allow adequate pouring of the molds.
4. The conveyor starting, stopping, and movement should not damage the mold cavity.
5. The mold travel time measured from pouring to shake-out should be long enough to take the cooling castings safely below the critical range of temperature.
6. Proper regard should be given to the possibility of excessive sand heating especially when the sand to metal ratio is low.

After an efficient system is set up it is easier to fit the existing conditions instead of changing the system. For example, a certain casting has a defect which is due to porosity. This might be corrected by decreasing the ram instead of changing the amount of moisture or bond content of the sand. If the sand is changed to cure one defect, it might cause others to ruin the production of many more castings. To change ram might necessitate changing the setup of several molding machines or other items in the production line to provide more efficient production. Changes in pouring, molding, and gating are other things which will save making changes in the sand composition.

To keep a constant sand composition a rigid sand inspection is needed. A good example of what such a system should consist of is the system used by the Pacific Cast Iron Pipe and Fitting Company. The sand testing starts when the sand enters the plant in railway cars. Each car load has a sample taken from it and tested. The sand is also checked every two hours for permeability, green compression, moisture, hardness, density, and dry shear. Also clay content, grain fineness and distribution, and total combustables are checked monthly. As soon as trouble appears these tests are repeated to find out what changes are necessary. For example if the sand becomes lumpy or shows signs of difficult shakeout the dry strength should be tested and any adjustments made. If the tests indicate that the dry strength is within the proper limits then other tests should be conducted.

The first check for defects is a visual check at the shake-out or in the buckets carrying the castings to the cleaning station. Any noticeable defects should be reported immediately so that proper adjustments can be made. The smaller and less noticeable defects are determined and classified by the inspection department. These defects are analyzed for the cause and eliminated by making the proper adjustments to either the equipment or molding and pouring procedures.

These combinations of sand control, equipment control, and rigid inspection have proven very successful for the Pacific Cast Iron Pipe and Fitting Company in providing efficient production. These or similar methods could be incorporated in most foundries to produce low cost production.

Sand screening provides a smooth and even sand surface against the pattern surface. Therefore, a smoother casting is made.

[1]Morris Gittllman, "System Sand Control," *American Foundryman*, Nov. 1954. Page 56.

Automotive
GAS TURBINES

by Siegmar Gresch, M. E. '58

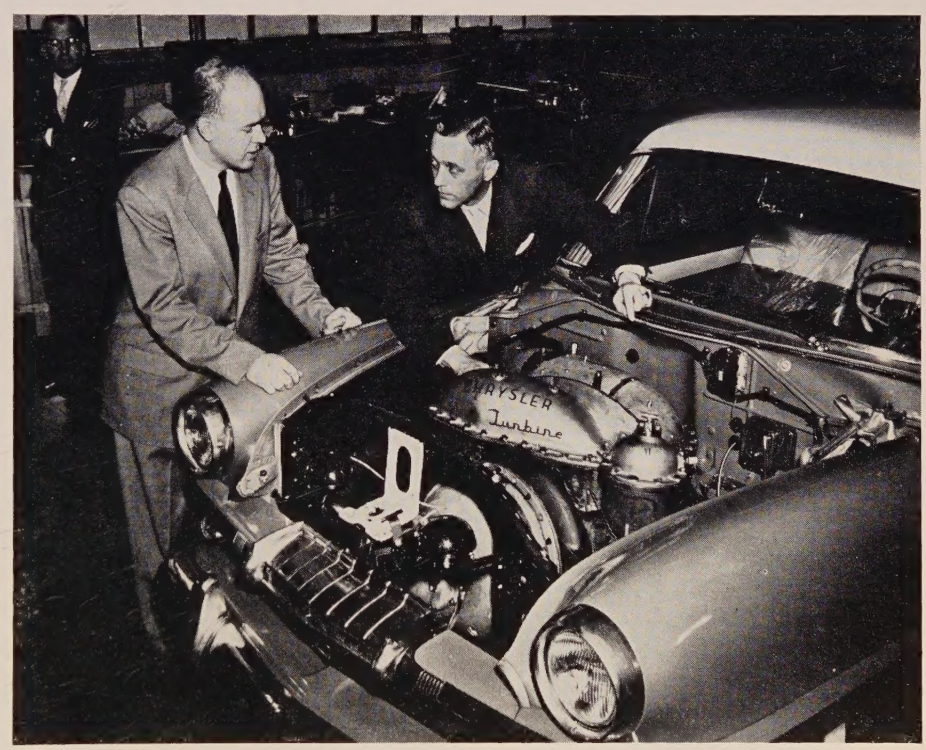
Last June, the Chrysler Corporation revealed an automobile that may revolutionize the car of tomorrow—a Plymouth powered by gas turbines. Several countries in Europe have had turbine powered cars for three or four years now. But, Chrysler is the first to develop a device called a "heat exchanger" or "regenerator" which in one stroke wipes out two major barriers of the turbo car; it cools the exhaust gases to the extent that people behind the car will not be burned, and it enables the turbine car to get the same mileage as a piston-powered one. The basic design is still secret, but former cars threw away half their power in exhaust. This heat exchanger permits a cooler exhaust, and therefore attains higher efficiency. The designer, George Huebner Jr., a young engineer at Chrysler, has found a way of capturing the hot exhaust gases and piping them back to the turbine to heat the incoming air. This serves two purposes. It saves fuel and cools the exhaust gases.

Let's take a look at the principles, advantages, and problems of the gas turbine. Up to a point the gas turbine in the automobile is like a jet aircraft engine. In both types, the rotary compressor forces air into the combustion chamber, where it is mixed with kerosene and ignited. The gas then expands, and on its way out of the turbine, gives up part of its energy to the turbine wheel. Now the resemblance ends. In the jet plane, the gases continue outward, and push the plane forward. This would be an impossibility in an automobile, since the hot gases would roast anything behind the car. A second turbine wheel is therefore placed some distance behind the first, permitting the gases to give up the rest of their energy to the second wheel which is connected to an automatic transmission.

Several companies have been working on building gas turbines but Boeing is one of the foremost. They have built several for the Armed Forces. The first in a Navy personnel boat. Others have been developed for use in helicopters, liason airplanes, engineers' pipe lines, pump sets, generator sets, portable air compressors, Army ordnance two and one-half ton trucks, switching locomotives, and Kentworth motor trucks and trailers. All these jobs were done with the same basic turbine.

The advantages of turbines are many. It does not have reciprocating parts and is much smoother and less noisy than a piston-type engine. Having one-fifth as many parts as a piston-engine it therefore uses only one-fifth as much oil. There is no need for a cooling system and the cost of a bulky radiator is eliminated. Its light weight, small size, ideal torque characteristics, flexibility of control and ability to operate on almost any type of fuel, make it ideal for use in transportation. No ignition system is needed except one spark plug, used in starting the engine.

Commercial demand for the gas turbine, has not developed because of the high manufacturing cost, high fuel consumption, and uncertain reliability and



The Chrysler Corporation's new gas turbine engine, mounted in a late model Plymouth. This engine saves fuel, cools exhaust, and attains a higher efficiency than the present day gasoline engines.

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The time was never more opportune than now for becoming associated with the field of advanced electronics. Because of military emphasis this is the most rapidly growing and promising sphere of endeavor for the young electrical engineer or physicist.

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As one of these field engineers *you will become familiar with the entire systems* involved, including the most advanced electronic computers. With this advantage you will be ideally situated to broaden your experience and learning more quickly for future application to advanced electronics activity in either the military or the commercial field.

Positions are available in the continental United States for married and single men under 35 years of age. Overseas assignments are open to single men only.

Hughes Field Engineer H. Heaton Barker (right) discusses operation of fire control system with Royal Canadian Air Force technicians. Avro Canada CF-100 shown at right.

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Culver City, Los Angeles County, California

life expectancy. The chief concern for the last few years has been the mechanical failures of turbine blades, turbine nozzles, compressor wheels, burner liners, gas seals, spark plugs, and shaft-bearings. But these troubles have been overcome by:

1. Developing safety factors against the wheel burst.

2. Eliminating wheel rubs from blade stretch, shrouding ring distortion and end movement of hot parts.

3. Eliminating blade base and blade airfoil failure from vibration fatigue, thermal shock cracks, and stress rupture.

4. Controlling starting and acceleration overheating.

5. Controlling unequal distribution of temperature in hot gas stream in order to avoid heat streaks.

6. Preventing blade damage from foreign objects in the gas stream.

7. Developing manufacturing and inspection techniques to assure consistency of quality in blades, wheel disks, and their assemblies.

In discussing the gas turbine, we come to the most difficult part to manufacture —the turbine wheel. Because of the high temperature and rotative stress encountered by this part, it is subject to tremendous strain and requires the utmost precision.

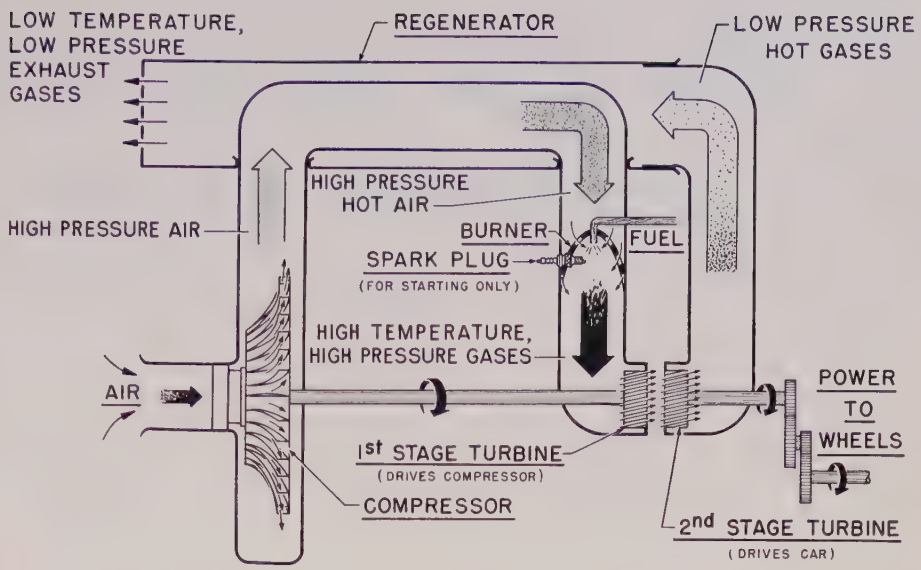
There are two types of turbine wheels, welded and machined. In the first, investment cast blades are welded to a disk type wheel. In the other, the shape of a fir-tree is machined into the circumference of the turbine wheel casting, and the blade is put into the segment cut out. This type of turbine wheel is used on aircraft engines because individual blades can be replaced. With small turbines this type is not very practical since the segment of rim circumference allowed for the blade tang is reduced considerably. It is possible to make wheels by welding cast blades to a forged disk, but X-ray inspection is difficult and rejects are apt to be high for a small defect in one blade rejects the whole wheel. A new type is the bi-metal cast wheel, there the hub is poured as a casting around individual pre-cast blades. This type has a great potential promise due to the low cost of production and that individual blades can be X-rayed and measured before casting.

All this work to make the turbine wheel as reliable as the current piston engines has made it impossible to reduce the manufacturing cost of the gas turbine. As a result of the pressure for reliability, there has resulted highly complex and exacting production requirements for the turbine wheels and their

nozzle assemblies, making their cost quite high. In testing these wheels, X-ray and Zygle inspections are used, and with the aid of these inspection methods, chronic types of weld defects can be controlled to a low occurence level. Many people believe that the material of which the turbine consists, is what brings the cost up. Actually, in a $1,000 turbine wheel only $40 is the cost of the actual material. $960 is the most of manufacturing.

One type turbine wheel, starting with the cast blade and ending with the balanced rotor assemble, required a total of 144 steps and 84 separate operations, and no less than 22 inspections of various types.

Study showed that handling time took 84% of actual flow time, as compared to 3½% machining time. This shows that the two major steps necessary to lower the cost of the turbine are reduction of number of operations, and reduction of chances of rejection. Operational welding would reduce the time considerably, and alqso provide better consistency. Elimination of base grinding to obtain a close fit would also cut off a few operations. By using various techniques, the total number of operations can be reduced by almost one-third and shop hours can almost be cut in half. This means a one-fourth reduction in the cost of producing gas turbines, and with mass production the cost would go down still further. With these facts in mind, engineers believe that a practical gas turbine is on the way, and that some day everyone will be driving a turbine powered automobile.



SCHEMATIC DIAGRAM OF
CHRYSLER CORPORATION GAS TURBINE

When Thomas A. Edison first put B&W Boilers to work in the Pearl Street Station, he launched a new industry of electric power which made possible an era of tremendous growth. Electricity—cheap, available, abundant—is the bedrock of America's strength. And certainly, this great pioneer envisioned all the wonders still to come, in the soft glow of his first practical lamp.

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The Use of Slots and the Boundary Layer Fence

by Harvey Roth, Aero E. '55

ABSTRACT

The main concern of this report is to examine what is being done today in the field of boundary layer control. This examination is accomplished by studying the two principle methods employed in this field, slots and the boundary layer fence.

For the analysis of slots, the slot mechanism, pumping equipment, disposal system, and porous cover (when employed) are first discussed. Each different variety of slot mechanism is then analyzed from test data obtained through its use. The test equipment and procedure is also presented in each case.

The only auxiliary equipment employed with the boundary layer fence is spoilers. The use of the fence, with and without spoilers, is discussed. The method of analysis is exactly the same as is used for slots. In both cases, an abundance of visual aids, charts and diagrams, are employed in order to provide greater ease of analysis.

The results of the various tests conducted with either slots or the boundary layer fence are then weighed against each other while keeping in mind the shortcomings involved and the ultimate gains obtainable for each system used. Upon the basis of all these factors, conclusions are drawn as to the probable future of slots and fences and upon the future of boundary layer control in general.

INTRODUCTION

The idea of "controlling" the boundary layer, as well as the foundation of boundary layer theory, was introduced by Prandtl in 1904 when he spoke "Upon Fluid Motion with Very Small Friction."[5]

Early progress in the field of boundary layer control was slow. This was due to the lack of suitable equipment, the difficulty encountered in the design of a duct construction capable of meeting weight and structural requirements and the lack of a sound theoretical background, the early work being of a very empirical nature. Nevertheless, by the outbreak of World War II, several experiments had been conducted in "sucking" the boundary layer through slots cut in existing airfoils. By 1944, ways had been found in airfoil design to produce any desired pressure distribution. This development caused a revival of interest in boundary layer control.[3]

At this point it would be well to define boundary layer control. Some authors classify it as anything tending to improve the boundary layer and even include such things as painting. On the other extreme it is defined "as a method of influencing flow with a source and/or sink."[5] For the purpose of this report, boundary layer control will be defined as any method of adding energy to the boundary layer, such as sucking away the low energy air, mixing air at higher energy levels into the boundary layer, etc.

The two main techniques of boundary layer control in use today are suction or blowing and the boundary layer fence.

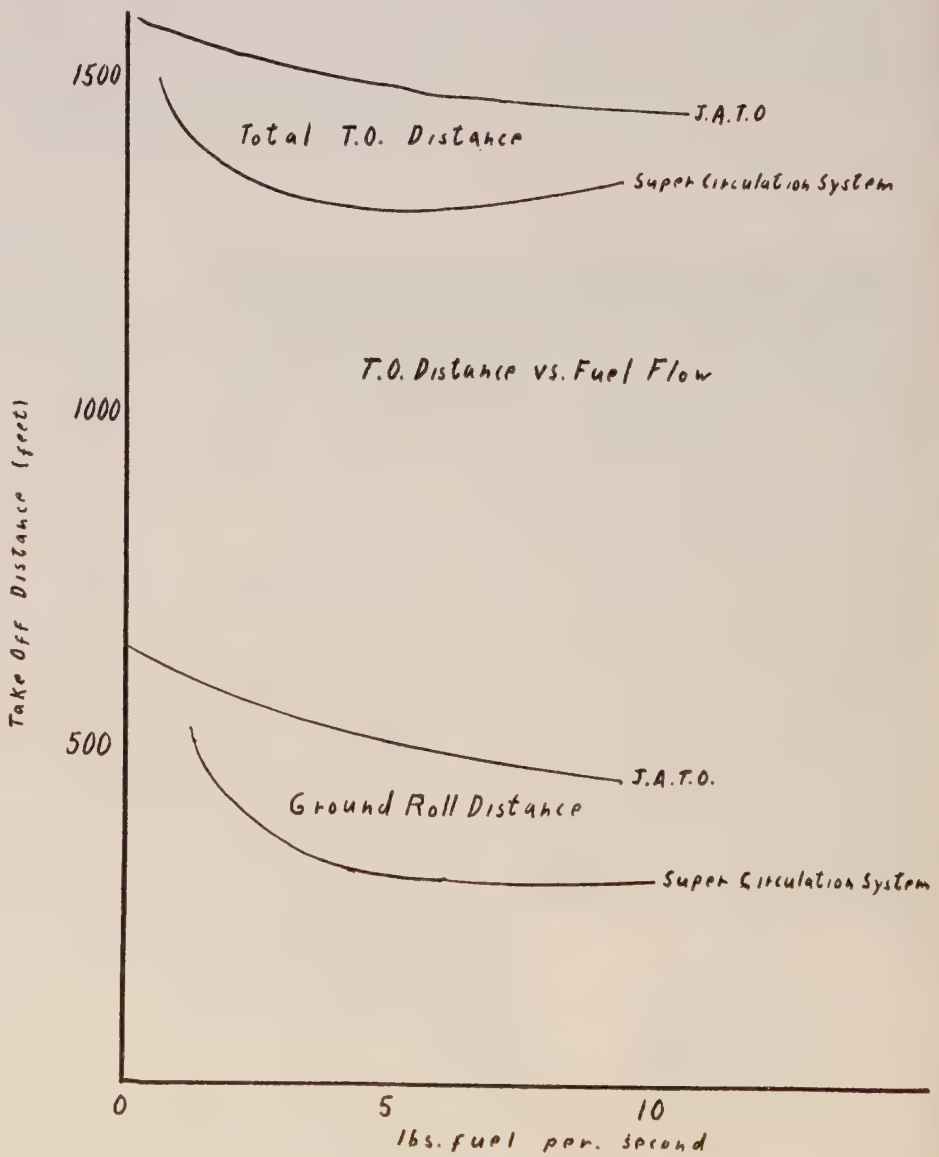

Figure 1[5]

The Use of Slots to Improve Landing and Takeoff Characteristics

Probably the most important advance to date in the field of boundary layer control is the use of slots. Although it is conceivable to use the same slots and the same air pump to increase lift as well as to decrease drag,[7] these two phases have for the main part been attacked separately.

In view of the fact that between 25 and 50% of all fatal civilian aircraft accidents are due to stalling,[2] a figure so high as to cause accident rates to be based on numbers of takeoffs and landings rather than on passenger-miles, it is seen that the more urgent aspect of problem is that of improving low speed characteristics. The wing loadings for military aircraft have more than doubled in the last ten years. Meanwhile the camber, and therefore the maximum lift coefficient, has decreased. From the equation $V_{stall} = \sqrt{K\,W/S\;1/C_{lmax}}$ it is seen that with our present day high wing loadings and thin air foils, the stalling speed will be sufficiently increased to cause trouble. Certainly the use of J.A.T.O. units, catapults and stop wires along the ground cannot be considered as permanent solutions.

Experiments with a Cessna 170

A series of tests have been run with a Cessna 170 equipped with boundary layer control system. The model employing the boundary layer control equipment was designated Cessna 309. The lift coefficient of Model 170 varied between 3.5 and 4.0.

In the inboard section of the wing on Model 309, air is sucked in through a slot. This disposes of the low energy air in the boundary layer and thus retards turbulent separation. This retarding of separation caused an increase in lift coefficient of as much as 1.9[6]. The sucked in air is then sent through a blower and blown out through a slot on the outboard section of the wing. This blowing out of the air over the upper surface of the flap re-energizes the boundary layer and super-imposes additional circulation strength on the field across the airfoil. It is due to this increase in circulation strength that this type of action is often referred to as super-circulation.[5]

The supercirculation adds an increment of lift comparable to that added by the sucking process and also increases the aileron effectiveness due to the rise in momentum.[6]

This increase in lift is felt by a decrease in stalling speed. In the case of the Cessna this amounted to a decrease in stalling speed of 15 m.p.h. The original stalling speed was approximately 50 m.p.h.[5] Landing distance was cut in half and a 40% saving in take-off ground run was also realized.

As a further demonstration of the improved stalling conditions acquired through the use of the super circulation system, level flight was maintained only a few feet above the ground at a speed 11 m.p.h. less than the normal stalling speed. One unpredicted feature of the super circulation system was the ability of Model 309 to take-off at a lift coefficient of 3.0, as compared to the lift coefficient of between 3.5 and 4.0 for Model 170. An improved angle of climb was also obtained. No reason has yet been found for this occurrence.[6]

This system was tested on an F-86 Sabrejet where it also showed very favorable results. The landing speed of the Sabrepet was reduced from 100 to 60 kuots and take-off distance was less than that needed when J.A.T.O. was employed (see Fig. 1). At a fuel flow of five lbs. per second, the normal ground run distance is 650 feet. With J.A.T.O. it is 570 feet and with the super circulation system it is only 300 feet. This system holds an even greater advantage over J.A.T.O. for naval use than for ground use due to the lack of a 50 foot obstacle (see Fig. 1).[5]

Boundary Layer Studies on a Sailplane

Considerable study has been done on the effects of boundary layer control using a sailplane as the test model. The sailplane offers many advantages as a research tool due to the lack of minimumization of noise which tends to cause an early transition. Another troublesome boundary layer hazard which is not present in this case is engine vibration. By having a low original level of turbulence, a much greater turbulence range may be explored. Even more important than this is the ability to add each unfavorable factor separately and thereby observe its relative effect.[1]

One such test was run to determine the relative merit of trailing edge suction which was proposed by Regenscheit near the beginning of World War II. Regenscheit's performance figures looked impressive until they were put to the test by Waltz, who claimed that the decreased friction loss amounted to less than 10% or an amount less than or only slightly more than the power needed to achieve suction. Waltz, furthermore, suggested placing the suction at a point 10% aft of the leading edge.[1]

Thus, arose the question, was Regenscheit's theory wrong or had Waltz merely used a poorly designed slot? The plane used to find an answer to this question was a TG-3A war surplus sailplane in which the rear cockpit was used as the observer post. On the inboard section of the wing, the upper cover was cut away just aft of the leading edge and was replaced by a canvas cover. False ribs were used to make the transition more gradual and the leading edge was made wave free within $\pm$ 0.002 inches.[1]

A traversing wake survey pitot was placed on the trailing edge of the wing and the observer was equipped with a stethescope attached to a probe with which he was able to determine any movement in and the location of the point of transition. In the turbulent section of the wing, a burbling or roaring sound is heard; in the laminar region a gentle hissing is heard. The point of transition is located where occasional bursts of turbulence are heard. In order to test Regenscheit's method, the slot was placed between 96 per cent and 98 per cent chord from the leading edge.[1]

The results were somewhat surprising and quite discouraging. The transition not only failed to be retarded but was even moved forward. This showed that the effects of trailing edge suction do not extend far enough forward to effect the laminar boundary layer. Therefore, any decrease in drag experienced must have been due to a decrease in pressure drag. The main effect of the trailing edge slot is to swallow the low momentum wake thereby decreasing the profile drag.[1]

Waltz's ten per cent slot showed a considerably greater increase in lift. This increase must be weighed against the higher power requirements at this position since much greater suction is needed to suck air in against the high negative pressure on the wing at this forward position.[1]

In T.M. No. 1181—Investigation on Reduction of Friction on Wings, in Particular by Means of Boundary Layer suction, published in 1947, Pfenninger claims that no amount of suction applied downstream will restore a laminar boundary layer once turbulence has set in. Whether this is so or not, it is well known that the entire boundary layer would have to be removed. This removal, if it could be effected, would require considerable suction, far in excess of the amounts normally employed for purposes of boundary layer control.[1]

Dr. A. A. Griffith, on the basis of the fact that if the pressure is made to decrease in the direction of flow, boundary layer separation will be retarded but that it is impossible to maintain this drop over the entire airfoil, suggested that the pressure decrease be allowed to continue to some point far back along the airfoil and at this point cause a sudden discontinuous rise followed by a gradual fall off of pressure. The slot may either suck away or re-energize the boundary layer at this position. Results obtained on an airfoil using Griffith's suggestions were very unsatisfactory. The results of a nose slot appear some-

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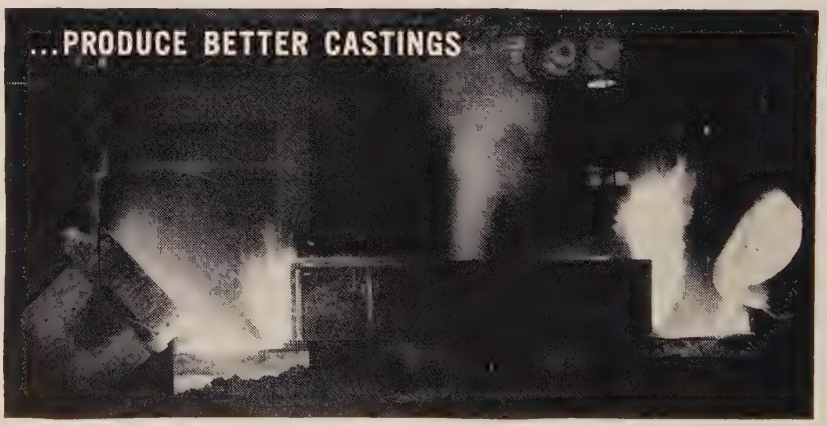

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what more impressive but even these are not really satisfactory.[3]

The Porous Area Method

The solution for slot design then seems to lie elsewhere, possibly in the use of a porous area and distributed suction. An air inlet placed at the leading edge of the wing carries the air from the pores of the skin to a blower in the cabin below. A porous leading edge is placed over this inlet. The porous leading edge consists of a monel metal filter cloth which has been rolled and hammered to reduce porosity. This is backed by a layer of bronze window screen and a thin sheet of perforated brass to increase the stiffness. The holes in this porous material are so small that light can hardly penetrate them.[4]

The Flight Research Division of Langley Laboratory has taken a conventional high wing personnel plane and substituted a porous metal skin over the leading edge of each wing. Ducts behind the skin are connected to an exhaust system which sucks air in through the skin and either blows it out over the aileron to increase control effectiveness or dumps it out of the fuselage, the former of course being the more satisfactory as was shown in the discussion of the super circulation system. This system smoothed the flow over the skin, caused an increase in lift and delayed the stall.[4]

Some difficulties Encountered in the Use of Boundary Layer Control

Thus, apparently, lies the answer to the problem, but unfortunately many difficulties are encountered in the application of any of the systems discussed so far. In fact, it may well be said that there are many "bugs" in the systems.

One obvious difficulty encountered is the space, weight and power requirements for the pump or blower. A wide variety of pumping equipment has been used.[5]

The first satisfactory application of suction was by the use of the Ardo System which was first used on the piston propelled Ardo-232. Decomposition of hydrogen peroxide provided high pressure steam which was used to run a jet pump.[5] A decrease in duct size is realized by this method when used for supercirculation since the same volume of air is utilized for both suction and blowing.[3]

A similar system was built by Razak which employed a unit supplying hot high pressure steam instead of the hydrogen peroxide jet pump. The efficiency of this unit was considerably lower than the Arado System. It was also considerably heavier. Its advantage was its ability to be used for pumping over a considerably longer period of time.[5]

Two rather ingenious methods of suction were suggested in the use of trailing edge suction. The first of these was to have an opening at the wing tip where, due to the tip vortex, a greater velocity and lower pressure exist. By utilizing the large pressure difference between the wing tips and trailing edge, the suction could be accomplished. The other method to be used with trailing edge suction was to cut a notch in the low pressure section of the leading edge through which air sucked from the trailing edge by pressure difference would also produce a blowing effect at the notch.[3] Although these methods seem quite ingenious, the results of trailing edge suction, as was discussed earlier, proved unsatisfactory.

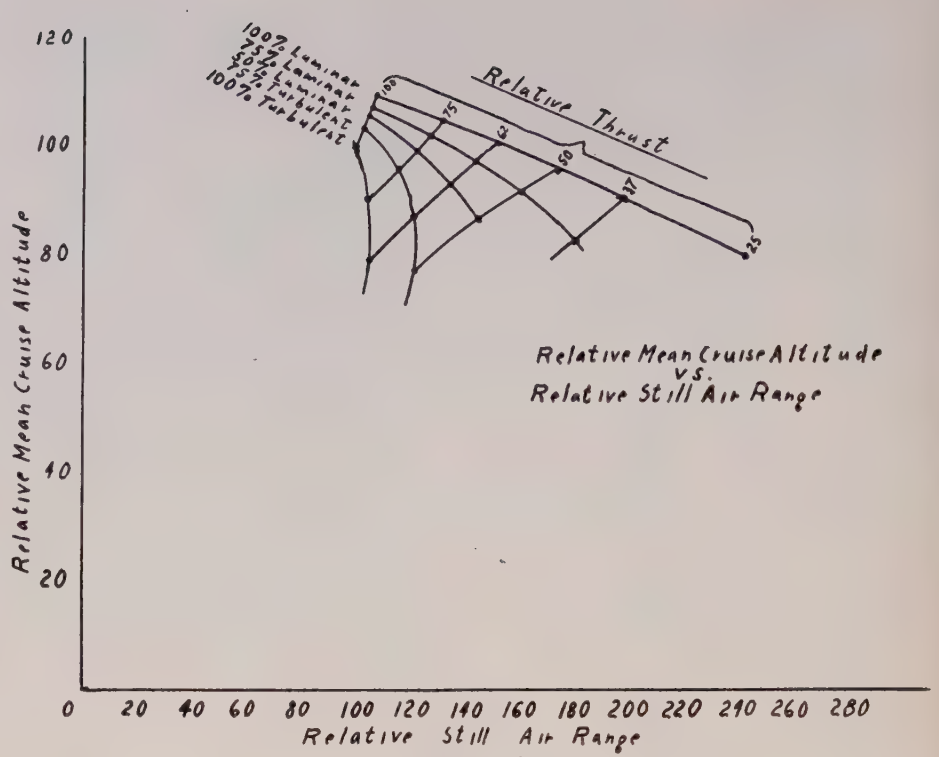

Figure 2[7]

A suggested method, for use in high speed aircraft, is to bleed compressed air from the turbine. This air would be used to drive high speed axial-flow fans to produce the pumping of air over the wings.[4]

A very critical feature in the use of slots is the slot design and location. A poorly or inefficiently designed or poorly located slot will tend to aggravate rather than alleviate the problem. This difficulty is not encountered in the use of a porous surface but the problem of clogging due to insects, dust, rain, etc., is much more critical in this case.[4]

Another defect encountered in the use of a porous surface is the tendency of the surface to produce a destablizing effect on the boundary layer when power is off. This is due to the increased surface roughness produced by the holes. Therefore if something should go wrong with the pumping equipment or should clogging occur, dangerous stalling conditions would be produced.[3]

Probably the most critical problem encountered in the application of boundary layer control is obtaining the proper amount of suction. Rapid forward movement of transition occurs at a suction pressure below some critical value. This critical value was found to be $p/q=1.28$ in the sailplane experiment.[1] This advancing of transition is due to the destabilizing of the boundary layer by local regions of outflow. Over sucking also tends to bring about an early transition due to roughness effects.[7]

Finally, the relative merits of suction and blowing should be considered. It is cheaper to use a blower but the quantity requirements are greater than those for suction. The higher quantity requirements would necessitate the use of thicker wings due to capacity limitations as well as the structural difficulties encountered.[3] Of course, the supercirculation system which utilizes both of these methods may possibly prove the best arrangement. The suction could be accomplished either by a slot or by a porous area while utilizing this system.[5]

Some answers have been given to the problem of clogging. One of these is to place the slot behind the furthest point where insects collect but, due to quantity requirements, as little behind this point as possible.[3] A second and more satisfactory answer is to cover the front of the wing with an expendable cover to be ejected at an insect free altitude.[3] Of course, with this method, either cleaning or replacing the porous cover would be necessary due to the dust collecting in the pores during landing.

Boundary Layer Control for Decreasing Drag

Drag decrease, although a less urgent problem than lift increase, promises to be the more noteworthy contribution due to boundary layer control. Not as much experimental literature has been published on the reduction of drag through boundary layer control although much of the theoretical development has been published.[7]

From this literature, it is evident that the ideal situation would be to maintain continuous distributed suction. This form of suction is, nevertheless, impossible, or at least, extremely difficult to maintain.[7]

Due to the complexity of the topic, the theory of the effects of surface roughness and waviness will not be developed. It is sufficient to say, for the purpose of this article, that extreme care must be exercised in limiting the amount of waviness and the size of an isolated roughness.[7]

One criterion set down was to limit the height of an isolated roughness to no greater than one half the displacement thickness and, in any case, to keep it less than the height of the boundary layer.[7] The waviness too must not become excessive. In the sailplane experiment, it was required to keep the leading edge wave free with ± 0.002 inches.[1] It is this high standard of required surface finish which rejects continuous distributed suction.[7]

Individual sinks, on the other hand, do not offer the advantages of the distributed suction. The optium condition probably lies between these two solutions, or in the use of many closely spaced spanwise sinks.[7]

At 0 incidence and a wind speed of 180 feet per second, transition on the upper surface occurred at 28% chord with a drag coefficient of 0.00322 without suction. With suction applied transition on the upper surface occurred at 93% chord with a wake drag of 0.00078 and a pump drag of 0.00037 or a total effective drag of 0.00115, a reduction of 64.3% as based on the original drag.[7]

Fig. 2 shows the variation of relative still air range with relative mean cruise altitude for various degrees of laminarization. An increase in range along any curve is maintained through the reduction of power plant size. Points representing a given weight and size of power plant are connected on the curves representing each different degree of laminarization. The cruising speed is maintained constant.[7]

It can be seen from the diagram that, by using the same power plant, laminarization does little to increase either the range or mean cruising altitude. This is somewhat deceiving though, since a corresponding increase in altitude for the turbulent plane would involve a sizable increase in power plant and a large decrease in range. Thus it is seen that the maximum gain in range due to laminarization would be obtained with a lighter power plant, with a corresponding decrease in thrust and a lower cruising altitude.[7]

The gains obtainable through laminarization by boundary layer control are, to say the least, impressive. The completely laminar aircraft has two and one half times the range of the turbulent one, its mean cruising altitude being about 20% less.[7]

Of course, a completely laminar aircraft would be somewhat impossible to obtain without imposing ridiculously high suction requirements. A more realistic criterion would be a 50 per cent laminar aircraft. Even this degree of laminarization would mean an increase in range of 45% as compared to the turbulent aircraft with a corresponding decrease in thrust of 50% and a decrease in mean cruising altitude of 14%. The "turbulent" aircraft referred to is a four jet transport for which the needed performance data could be obtained.[7]

If the range of the turbulent aircraft is satisfactory a decrease in fuel consumption could be realized instead. This decrease could in the case of a jet transport be converted into extra passenger and baggage weight.[7]

Due to the reduction in size of the power plant, an unorthodox arrangement could be utilized such as placing the power plant at the tail end of the fuselage. This would reduce the drag of the power plant to a minimum and, in the case of passenger aircraft, would afford the additional advantage of placing the passengers in front of the noise cone.[7]

The fuel saving realized due to laminarization would mean a sizeable increase in revenue for passenger aircraft. It has been estimated, for the British Comet, that a reduction in fuel weight, for the trans-Atlantic crossing of five per cent, converted into additional passengers, would cause an annual revenue increase per aircraft of $560,000. For fighter aircraft, the decreased drag could be utilized for increased cruising speed and the greater maneuverability which accompany a lighter air craft.

The Boundary Layer Fence

As was mentioned earlier, it is possible to use the same system (slot and pump) to both increase the lift and decrease the drag. It, nevertheless, would be difficult to get a pumping system capable of performing both of these functions. It may be more advantageous to use slots and the systems already discussed to decrease drag and utilize some other method to increase lift. One such possible method, showing much promise, is the boundary layer fence.

Work on the boundary layer fence began in 1938 in Germany. The Mes-

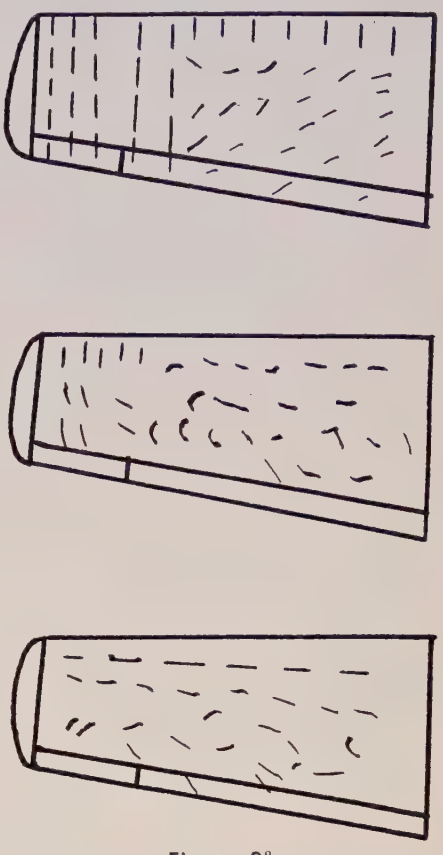

Figure 3[2]

The lines shown are strings taped to the airfoil which show the direction of the air flow.

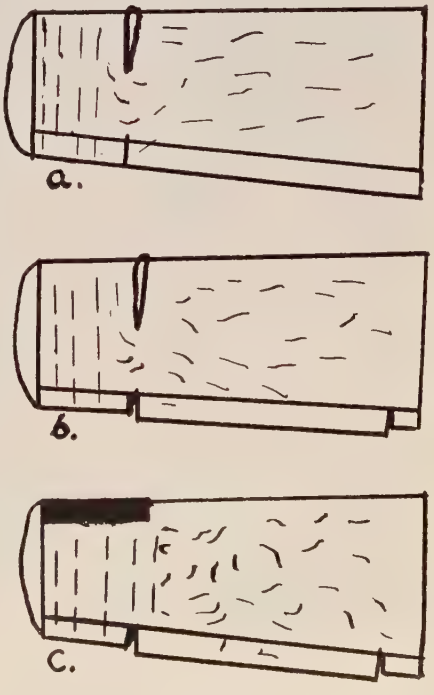

Figure 4[2]

serschmitt ME 109 had at the time been using slots but still had very poor landing characteristics and many pilots were being killed due to sudden rolls on landings.[2]

Pieces of thread were taped to the wings of a Messerschmitt and a camera was used to take photographs of the flow every 0.5 seconds. The results, shown in Fig. 3, indicate a decided cross flow which occured only on one side. The question was whether the cross flow was a secondary effect or the actual cause of the sideway break away of flow.[2]

It was assumed that the cross flow was the cause. Thus the problem was to stop the cross flow. The solution was the boundary layer fence which is nothing but a piece of metal ten centimeters high, placed perpendicular to the wing surface. Fig. 4 shows the flow pattern over the same airfoil as was used to obtain the flow pattern in Fig. 3, in this case, using a boundary layer fence. From Fig. 4, it is seen that the fence stopped the cross flow, retarding the break away of flow.[2]

Flight tests, using the fence, showed a decided reduction in roll near the stall at the cost of a negligible reduction in cruising speed. The cross flow problem is greater for a swept wing and the use of a boundary layer fence is an even greater contribution to swept wing aircraft. The structural simplicity of the boundary layer fence makes possible its addition to planes not designed to use it.[2]

Cross flow is caused by the sucking up of the inert surface air by the low pressure air above it. This creates eddies and piling up of air which is carried out along the span causing cross flow. Cross flow appears to be most critical for the very airfoils which provide the best performance. The fence stopped the flow of the inert boundary layer air outward causing it instead to be sucked upward into the higher energy air above and thereby re-energize the boundary layer.[2]

The boundary layer fence, shown in Fig. 4, placed at mid span, was not the complete solution though, since the flow was still disturbed inboard of the fence and the rolling problem, although somewhat alleviated, was not really solved. Moving the fence inboard only caused a mid wing break away of the flow without cross flow.[2]

Thus, the problem was to get all of the disturbance to occur over a very small inboard section. This was accomplished by using spoilers at the wing root to cause the break away to occur at the root section coupled with a boundary layer fence placed next to the spoilers to stop the disturbance from spreading outward. This combination almost completely eliminated cross flow, limiting it to an almost negligibly small section at the root.

Tests were run on the ME 109 to determine the variation of angle of attack, lift coefficient, and bank with time, using the fence and spoilers as compared to the variation on the same airfoil without fence and spoilers. The results were that the reverse roll characteristics formerly possessed by the ME 109 were almost completely eliminated with no sacrifice in lift.[2]

Some of the planes using the boundary layer fence today are (1) the twin engined De Haviland, D.H. 110 jet fighter, (2) the De Haviland, D.H. 106 "Comet," (3) the S.N.C.A. du Sud.-Est. "Mistral" jet fighter, (4) the Mi G-15 (four fences) jet fighter and (5) the Trojan A-2 sports two seater. The most novel use of boundary layer fences is that employed by the Trojan A-2. In this plane, the wing ribs are fitted outside the stressed skin. The ribs therefore act as boundary layer fences.[2]

Conclusions

This completes the boundary layer picture. From the point of view of stabilizing the laminar boundary layer, the theory looks promising but all that exists is the theory. As far as improving landing and take-off characteristics, much has been done in testing new techniques but nothing really satisfactory has been found.

The critical design and location of slots seems to warrant their abandonment in favor of distributed suction. Distributed suction, on the other hand, shows many pitfalls and much work is still needed there. The use of "gadgets" such as boundary layer fences and spoilers shows some promise but the fact that "gadgets" have to be resorted to at all only further proves the inadequacy of the work done so far. Certainly, the gains offered by boundary layer control warrant the abandonment of our former and present day indifference. A concerted effort in boundary layer research when initiated, promises great dividends for the labor invested.

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Illini Rocket Inquiry

by Jim Piechocki, Aero. E. '56

Maybe we're just plain immature, but whenever the word "rockets" is mentioned, we engineering students tend to prick up our ears, drop our slide rules and homework, and pay strict attention to the discussion at hand. In no time at all we are an integral part of the bull-session, tactfully displaying our dexterity at cracker-barrel philosophy. So

JIM PIECHOCKI

Jim, a junior in his second semester on this campus, has previously written articles for the TECHNOGRAPH while at Navy Pier. He is now busy in organizing an openhouse program for the Aerodynamics department.

when someone mentioned the other day that the Aeronautical Engineering Department was inaugurating a rocket research program, another round of coffee was ordered, and bull-session experts (of the engineering student species) took up the conversation with a new fervor. But such terms as "interplanetary travel," "space stations," "galactic drives," etc., filtered into the confab and eventually clouded the sincerity of the original purpose of this elevated discussion, leaving the more down-to-earth type of student at a loss for words. Hence, this reporter decided to get the firsthand "scoop" from the man behind the program, Dr. T. P. Torda, of the Aeronautical Engineering Department. Dr. Torda, despite his rigid schedule, very cordially granted an interview to the Technograph. The interview was eagerly anticipated by this writer—and with good reason: Dr. Torda, besides being this observer's nomination for the title of "the busiest man on campus," has the most vivid sense of humor north of Green Street. So when the time arrived for the inquiry, with pencil in ear, paper in hand, and a few leading questions in mind, we opened the door to the office marked Dr. T. P. Torda and were met with the remark, "Well, what do you want to know?" What followed went something like this:

Just how interested is the Aeronautical Engineering Department in rocket reseach?

I would say that we are very interested.

Is the department now conducting reseach in the field of rocketry?

Yes. We have already begun reasearch on two analytical problems in this line, and are looking forward to expansion of the entire program. I have prepared a proposal for a program of experimental sponsored projects dealing with basic combustion and combustion chamber problems.

How extensive is the program now?

As I have said, work has already begun on two analytical problems. One of them concerns the phenonemum of high frequency oscillatory combustion. The other deals with finding an optimum shape of the combustion chamber. Both are Air Force projects. Our facilities at present are somewhat limited. A little rocket shack out at the University airport is the only structure we have that is entirely devoted to rocket study alone. Plans are being drawn up for the construction of a special test stand. The Illinois Rocket Society is also conducting preliminary studies leading to the design of a rocket motor.

How does the Illinois Rocket Society fit into the picture?

The Illinois Rocket Society was formed by students early in 1953 for the purpose of promulgating the study of rocketry at the U. of I. At present it consists of twenty-three members, most of which are engineering students. Liberal arts students have also joined the society. I would like to stress the fact that the IRS is not a "club," but an organization which, through hard work, hopes to eventually become recognized at a professional level and on a national scale. The aims of the society are chief-

Dr. Torda, head of rocket research at Illinois and an authority in the field, feels that rocket design today is more of an art than a science. (Photo by David Komyathy)

ly to study the various fields of rockets and their applications, which includes exterior and interior ballistics (viz., flight and combustion). Their immediate aims are the design of a test stand, instrumentation, and a rocket motor for preliminary tests. We hope to cover every possible field of rocketry. (Note: Dr. Torda is the faculty advisor to the IRS.)

The IRS provides an excellent opportunity for interested students to put their ideas to work on practical problems. If he plans to continue his studies in an associated field, he has a good start.

What are the advantages of having a rocket reseach program on this campus?

There are very few fields of engineering science which require more research than the field of rocketry. Right now there are too many things that we know too little or nothing about. All too often phenomena arise which baffle us. Any rocket research program strives to better this condition. Since industrial research is devoted to applied problems, we will be able to handle problems which industry is not equipped to solve in addition to questions of great interest to the manufacturer.

The opportunities afforded to senior and graduate students are numerous. Look at the various colleges and universities with rocket research facilities. Purdue has for years under Dr. M. Zucrow maintained a rocket research laboratory. The California Institute of Technology maintains a rocket research lab at Pasadena. Princeton and the University of Michigan maintain similar facilities. The stimulating effect of the facilities has been impressive. Student interest in rockets on this campus is high. This is a good sign. The efforts of the Illinois Rocket Society can cultivate these interests and put them to good use.

What about rocket courses in the regular aero curriculum?

Look at the curriculum now. We offer a 300-level course in rocketry for graduate and advanced undergraduate students. Through it, we introduce the student to rocket design and present to him discussions on solid and liquid rockets. Various aspects of aerothermodynamics and chemical kinetics are also discussed. Our plans for the eventual design of a rocket motor are linked to future usage of the unit in this course. Then too, we are planning a graduate course dealing with a more detailed study of actual problems in rocket motor design, such as structural, combustion, and feed system design. Future plans also include a few rocket experiments per semester in the propulsion laboratory.

Getting a little more general, what are some of the big problems hindering rocket development?

A very big problem is the occurence of low and high frequency oscillatory combustion in rocket chambers. This is sometimes called combustion instability. Rapid pressure variations in the chamber are coupled to feed line and structural vibratory modes which are in turn governed by the elasticity of the structure. High frequency oscillatory combustion occurs in large-size rockets of both the liquid and solid propellant type. It is the least understood rocket phenonemon. A tremendous amount of research is required here. Heat transfer through the walls from the combustion chamber is a very complicated phennomenon of great interest. By far the biggest problem in industrial rocketry is the lack of knowledge of the scale effect in building larger motors. The problem of constructing a large rocket engine incorporating the features of a smaller successful unit is an art. We would like to make it a science.

Do you feel that since most of the early rocket research was handled by "enthusiasts", progress has been hampered and industry was inclined to "sneeze" at early efforts?

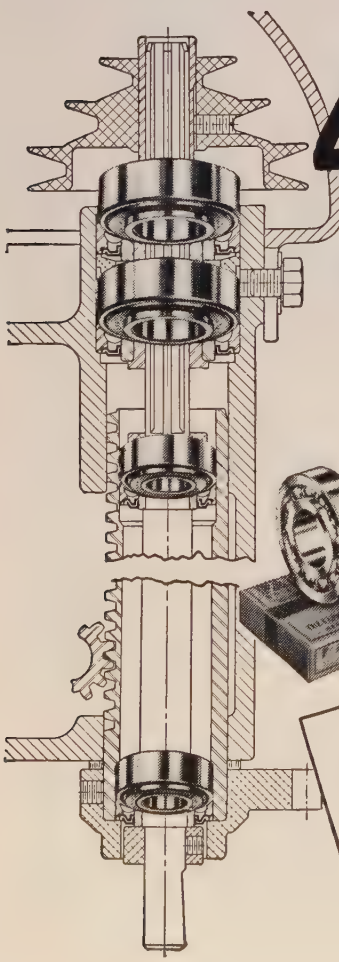
It is true that early efforts were hampered by men who placed emphasis on sensationalism. Opel was an example. But as some of these enthusiasts did valuable work, I don't think industry 'sneezed' very hard at their early efforts. Take von Kármán, one of the most distinguished men in the aeronautical world today. He and his students founded Aerojet and built the first useful solid fuel rocket. And von Kármán is no sneezer. Consider that Aerojet, a subsidiary of General Tire and Rubber Company, has been doing excellent work in the field of rocketry.

How do you feel about the future of rocketry?

Chemical and atomic rockets will be very important for missile work and high-speed planes. But there is still a vast amount of research required, especially in the field of basic combustion. The formation of a rocket research program here at the University is a step in the right direction.

Lady (to porter): Have you a ladies' waiting room?

Porter :No, ma'am. But we have two rooms for ladies who can't wait.



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The spindle of a popular electric power tool for hobbyists literally floats on four Fafnir pre-lubricated Mechani-Seal Type Ball Bearings. Since the power tool operates in both vertical and horizontal positions and under varied conditions . . . as a circular saw, vertical drill, wood lathe, disc sander and horizontal drill press . . . the bearings are extremely important to its accuracy and life. With saw blade at full speed, coins upended on hobby tool table will not fall over . . . a tribute to rigidity gained from use of Fafnir Ball Bearings. Opportunities for product improvement through ball bearing applications are almost limitless. The Fafnir Bearing Company, New Britain, Conn.

Available
A motion-sound picture depicting high points in manufacture and use of Fafnir Ball Bearings is available to engineering classes. Write to The Fafnir Bearing Company for details.

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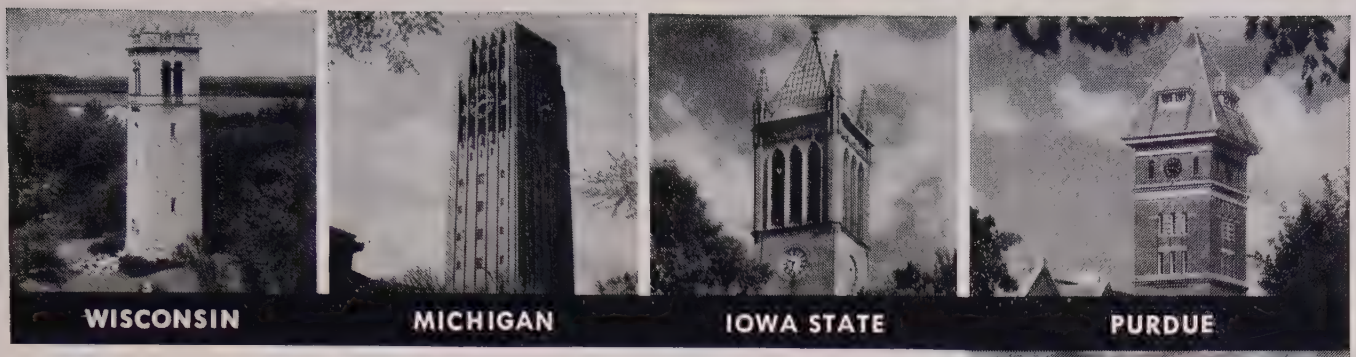

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Year after year, we draw on these nine schools for electrical, mechanical, industrial and general engineers.

If you are looking for a future with real opportunities for growth and advancement, Square D has a lot to offer. The potential growth and development of the electrical industry is tremendous—doubling every ten years, in fact. And Square D is a long established, top ranking name in that expanding industry. Equally important, Square D offers the kind of personalized training that equips you to go far . . . *fast!*

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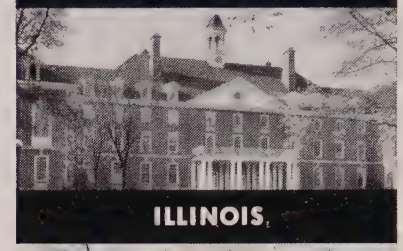

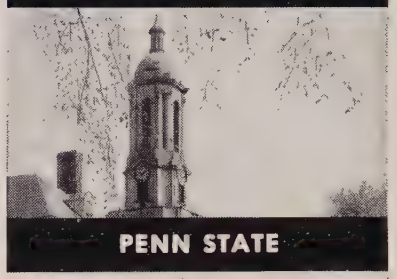

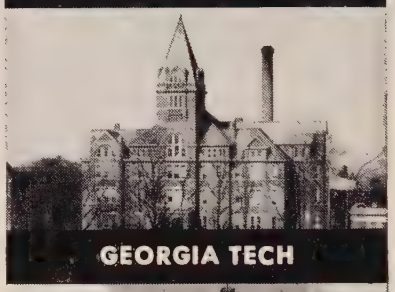

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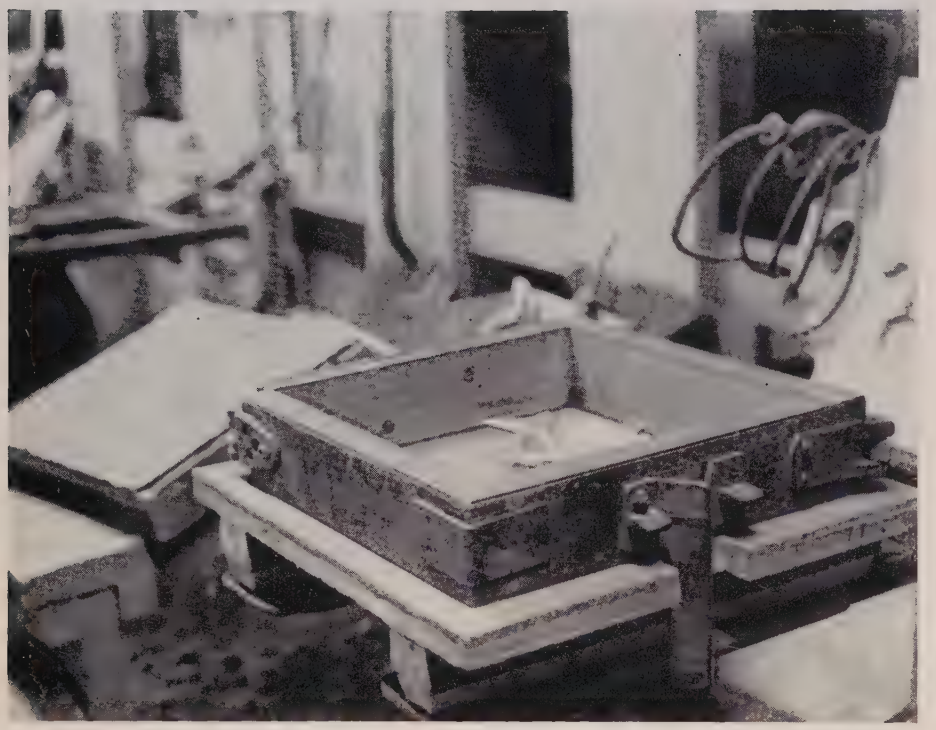
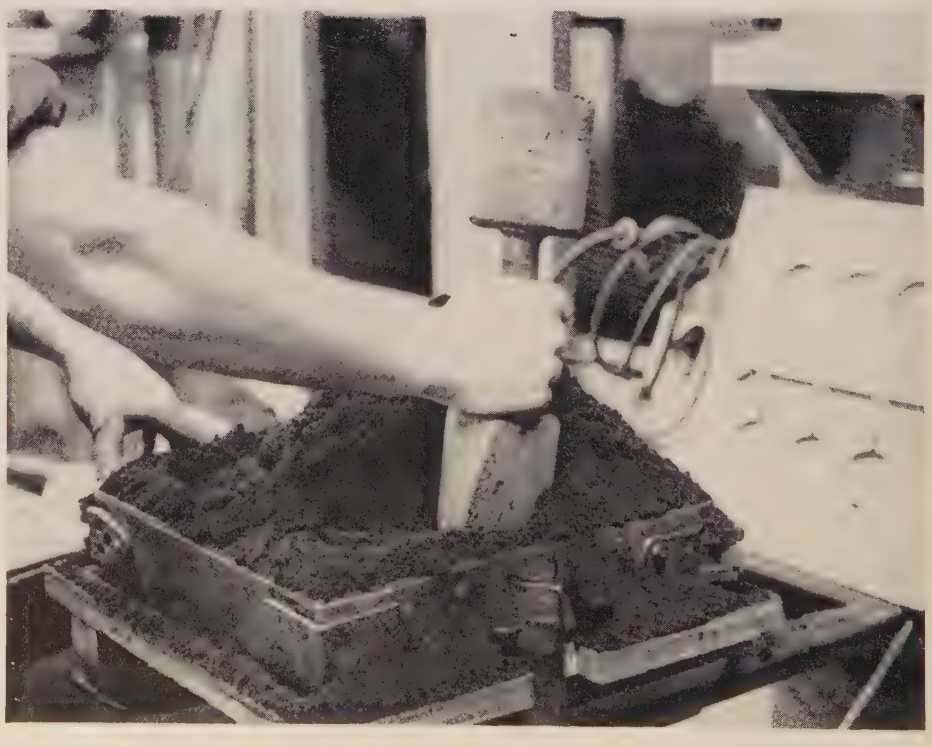
The Bench M

by Robe



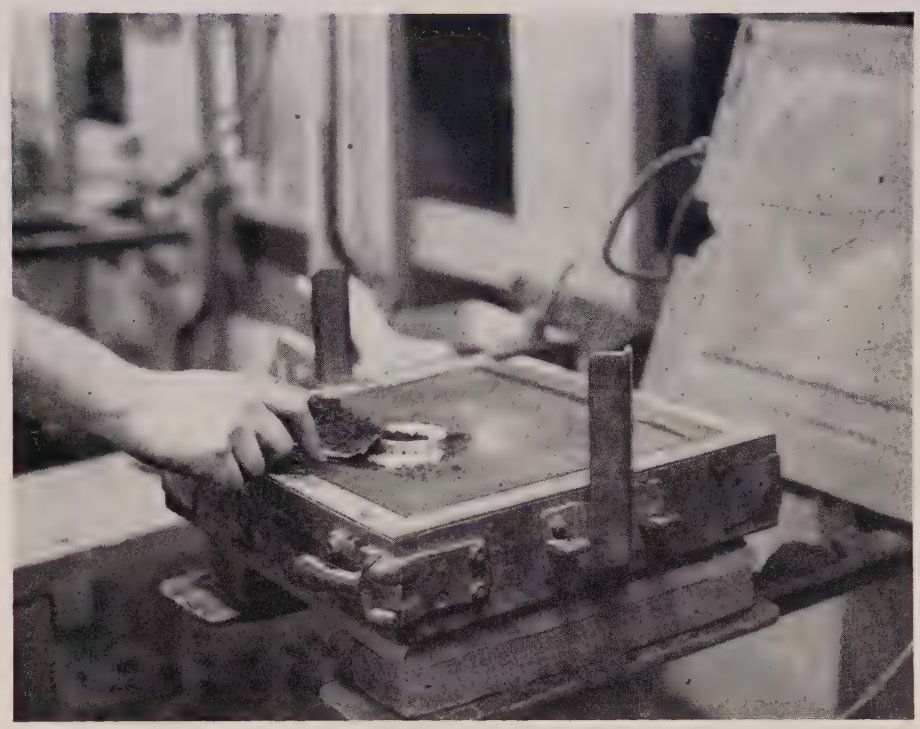
The molding process begins with the placement of the drag half of the flask on a molding board in an inverted position with the joint side resting on the board, the pattern can be seen lying on the molding board inside the flask.

The flask is filled to the top with sand and peen rammed firmly around the pattern and along the perimeter of the flask. The function of the peen or wedgeshaped end of a bench rammer is to pack the sand uniformly throughout the depth of the flask.

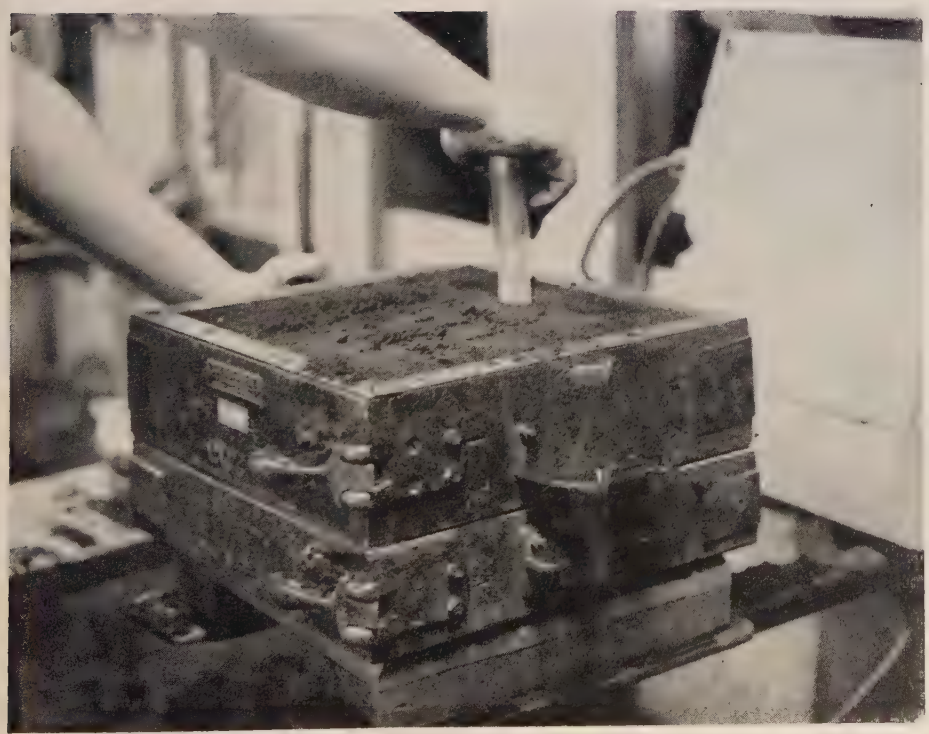


lding Process

M. E. '57



The drag is turned over, so that the pattern is facing up. Sand is being cleared away from the pattern to make possible the withdrawal of the pattern after the cope has been made. (Photographs by Al Shiner)



The cope half of the flask is placed in position over the drag, and the sprue pin is located near the pattern where the gate will be constructed. A sprue pin is usually a slightly tapered round wood pin, used to form a hole through the cope for the purpose of admitting molten metal to the mold cavity.

NEW METHOD SIMPLIFIES WELDING

A new method of welding that eliminates skills normally required, and claimed to be as easy as turning on a light switch, promises to make it possible for the rapidly growing number of home fixit-yourself and hobby craftsmen to work with metals as readily as with wood. It is expected that the method will also be useful to business and service establishments such as bakeries, hotels, bottling plants, hospitals, body shops, repair shops and other users of metal equipment and machinery that occasionally need a quick, easy method of repair or maintenance fabrication.

The Lincoln Electric Company of Cleveland, Ohio, has developed the new method, called Selfweld, to creat a quick, fool-proof method, usable by everyone, of joining metals for repairing and making such things as metal furniture, household and business equipment, tools, toys and automobiles. Lincoln has also developed a new 100 ampere welding machine for use with Selfweld. The machine, complete with electrodes, Selfweld holder and accessories, costs less than $100.

Selfwelding is said to eliminate the difficulties that would be encountered normally by the amateur in learning the skill of manipulating the welding electrode and controlling the arc. The new method employs a special welding electrode and special electrode holder. To make a weld, the tip of the electrode is simply held against the metals to be joined at the point where the weld begins, a switch on the holder is pressed to fire the electrode, and the electrode, as the tip is held against the metal, automatically makes the weld itself. The electrode and holder normally do the work required of the person welding. Locating the beginning of the weld, starting the arc, feeding the electrode, the electrode angle and the travel speed are controlled automatically by the design of the electrode and holder. A supporting leg on the holder can be used to help locate and steady the electrode on the joint and to control the angle of the electrode. The coating of the electrode touches the work at all times so that the arc length is automatically determined. The melt-off rate automatically controls welding speed. Excellent welds are made on the first try, it is claimed.

This Selfweld, made by the Lincoln Electric Company of Ohio, reduces the skill required in welding to that of a common home craftsman.

PROBLEM:

How Many Cigarettes?

Five men are in poker game: Brown, Perkins, Turner, Jones, and Reilly. Their brands of cigarettes are Luckies, Camels, Kools, Old Golds, and Chesterfields, but not necessarily in that order. At the beginning of the game, the number of cigarettes possessed by each of the players was 20, 15, 8, 6, and 3, but not necessarily in that order.

At a certain time during the game, when no one was smoking, the following conditions exist:

(1) Perkins asked for three cards.

(2) Reilly had smoked half of his original supply, or one less than Turner smoked.

(3) The Chesterfield man originally had as many more, plus half as many more, plus 2½ more cigarettes than he now has.

(4) The man who was drawing to an inside straight had absent-mindedly lit the tipped end of his fifth cigarette, the last one he smoked.

(5) The man who smokes Luckies had smoked at least two more than anyone else, including Perkins.

(6) Brown drew as many aces as he originally had cigarettes.

(7) No one had smoked all his cigarettes.

(8) The Camel man asks Jones to pass Brown's matches.

How many cigarettes did each man have to begin with, and what brand?

(Answer on Page 44)

QUARTZ CRYSTALS

How a 1¼ hour "gem-cutting" operation became an 8-minute mechanized job

PROBLEM: Preparing quartz crystals for use as electronic frequency controls calls for the highest degree of precision. So much so, in fact, that prior to World War II skilled gem-cutters were employed to do the job.

But during the war, there were not enough gem-cutters to keep up with the demand for crystals in radar, military communications and other applications.

Western Electric tackled the job of building into machines the skill and precision that had previously called for the most highly skilled operators.

SOLUTION: Here is how quartz crystals are made now—by semi-skilled labor in a fraction of the time formerly required:

A quartz stone is sliced into wafers on a reciprocating diamond-edged saw, after determination of optical and electrical axes by means of an oil bath and an X-ray machine. Hairline accuracy is assured by an orienting fixture.

The wafers are cut into rectangles on machines equipped with diamond saws. The human element is practically eliminated by means of adjustable stops and other semi-automatic features.

The quartz rectangles are lapped automatically to a thickness tolerance of plus or minus .0001". A timer prevents overlapping. Finally, edges are ground to specific length and width dimensions on machines with fully automatic microfeed systems.

Most of these machines were either completely or largely designed and developed by Western Electric engineers.

RESULTS: With skill built into the machines —with costly hand operations eliminated— this Western Electric mechanization program raised production of quartz crystals from a few thousand a year to nearly a million a month during the war years. This is just one of the many unusual jobs undertaken and solved by Western Electric engineers.

Quartz stones are cut into wafers on this diamond-edged saw, with orientation to optical axis controlled by fixture. This is just one of several types of machines designed and developed by Western Electric engineers to mechanize quartz cutting.

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

Manufacturing plants in Chicago, Ill.; Kearny, N. J.; Baltimore, Md.; Indianapolis, Ind.; Allentown and Laureldale, Pa.; Burlington, Greensboro and Winston-Salem, N. C.; Buffalo, N. Y.; Haverhill and Lawrence, Mass.; Lincoln, Neb.; St. Paul and Duluth, Minn. Distributing Centers in 29 cities and Installation headquarters in 15 cities. Company headquarters, 195 Broadway, New York City.

Recognized Minimum Standards

A *"Recommended Minimum Standard"* for commercial carbon steel castings, developed by the Steel Founders' Society of America, is ready for distribution to users and producers of steel castings. This is the first "Minimum Standard" in the century long history of the Steel Casting Industry.

This "Standard" is the outgrowth of studies made by the S.F.S.A. Product Development Committee and subsequent recommendations calling for its preparation. Succeeding work and its ultimate drafting became the task and the accomplishment of the Specifications Committee. Thorough discussion in each of the eight society divisions throughout the country focused the practical technology of the entire Society's membership into its final composition.

Acceptance of the "Standard" will be voluntary on the part of both the customer and the steel foundry source of castings. It is not expected, nor is it intended that it displace other specifications now in use. It does, however, establish a firm basis by means of which the purchaser and the supplier of general commercial cast steel components can arrive at a common understanding. It represents a common sense approach to a fuller use of the properties inherent to cast carbon steel. With this "Standard" the Steel Founders' Society of America goes on record as advocating the purchase and sale of carbon steel castings in a preferable physical and metallurgical condition.

The "Standard" emphasizes that its requirements are minimums and that they are not designed to influence in any way the production of castings which are practical improvements on such minimums. It is intended that all clauses apply unless otherwise agreed upon by producer and customer.

Quality control procedures, primarily in regard to physical and chemical properties, will govern production of steel castings under conditions set forth in the "Recommended Minimum Standard." Control of these properties implies a need for similar techniques in the selection of raw materials and the processing steps through the melting and heat treating cycles. Quality control procedures are a growing factor in steel casting production. Selection and control of sand properties, selection and use of scrap, relationship of casting size and shape to metal pouring temperatures, required temperatures and treatment for proper alloying, rate of heat input in both melting and heat treating, process inspection, mold cooling cycles, and variations in dimensional shrinkage are a few of the items in a steel foundry that lend themselves to such techniques.

Heat treatment of steel castings is emphasized. The "Minimum Standard" recommends either full annealing, single normalizing, or tempering (stress relieving) as desirable treatments. Research reports and literature issued by the Steel Founders' Society have identified the improved design properties achieved by heat treatment. A machinability research shows that heat treatment improves the machining characteristics of cast steel, an important factor in the cost of metal components.

Note is also made as to the desirable practice of furnishing a casting drawing along with pattern equipment. Under this condition the foundry assumes the responsibility for checking to insure accurate dimensions in the finished casting. Such action is particularly important when attempting to use equipment originally made for other metals or when wood patterns are stored for periods of time. The growth and contraction of wood with the seasons is sufficient to throw long dimensions out of line or warp a pattern in such a manner as to create an out-of-shape casting. This fault is particularly true of the so called "inexpensive patterns."

Methods for maintaining specified physical and chemical properties are set forth in the body of the "Standard." Variations in the chemical content are subject to constricting totals designed to give proper metallurgical balance. Inspection requirements as to external quality are at the visual level with dimensional limits checked by gauges and fixtures where required.

During the development of the "Recommended Minimum Standard" several foundries adopted the practices advocated as a basis for their own operation. There will be applications and production, however, where the quality level set forth in this Standard is not required. It must be emphasized that the use of this Standard is a matter of voluntary agreement between the foundry supplying the steel casting and the buyer.

The creation of this "Minimum Standard" is a natural and logical outgrowth of activities within the Steel Founders' Society. Today, some thirty research projects sponsored by the society are published and available to its members. Some portions of these are supplied to customer industries as guides in the use of steel castings. Twelve additional projects are under way and others are contemplated. All of these are directed toward the improvement of steel casting production methods and the metallurgical and physical properties of the various carbon and low alloy cast steels.

Technical and operating conferences in each of the eight divisions of the society are continuously developing the use of information coming out of this research program, as well as providing a medium of free exchange for operating and technical ideas among the steel foundries in a given area. The ninth National Technical & Operating Conference was held this fall on November 3, 4, and 5, in Cleveland, Ohio.

Paralleling these activities is an active product development program designed to discover new steel casting applications and improve the design of cast steel components. Among the duties of the Product Development Committee are the promotion of casting quality, design, and new products.

The "Recommended Minimum Standard" becomes one of the first steps in a marketing program now being initiated by the Steel Founders' Society of America. Quality, dependability, and reliability are marketing instruments in themselves. Improved physical and chemical properties constitute another market improving device. The adopted "Standard" promotes these factors.

Copies of the "Recommended Minimum Standard," as well as a booklet entitled "The Machinability of Cast Steels" are available free upon request to the Steel Founders' Society of America, 920 Midland Building, Cleveland 15, Ohio.

Recommended Minimum Standard for Commercial Carbon Steel Castings . . .

adopted by

The castings are now on the way to the grinding room

STEEL FOUNDERS' SOCIETY OF AMERICA

This recommended minimum standard is applicable to steel castings commonly referred to as "commercial carbon steel castings" (readily weldable grade).

This minimum standard shall apply only when no customer specification, calling for another order of quality, is made a part of an order.

It cannot be too strongly emphasized that the requirements of this standard are suggested minimums, and that they are not intended to influence in any way the production of castings which are improvements on these minimums.

It is the intent of this recommended minimum standard that all clauses apply unless otherwise agreed upon by producer and customer.

A—Material and Workmanship

A-1. The castings shall, as determined by visual examination, be free from cracks, shrinkage cavities, hot tears, swells, scabs, blowholes and pinhole porosity, that impair the utility of the castings.

A-2. Castings shall be free from sand and scale on all surfaces to the extent that normal machining operations can be performed without the necessity for further cleaning by the customer.

B—Detail Requirements

B-1. Castings shall have gates and risers removed in such a manner that no riser or gate stub projects beyong the casting design contour in an amount that would exceed the following values:

Riser or Gate Maximum Dimension inches	Maximum Projection inches
Up to 4	1/8
4+ to 8	1/4
8+ to 20	3/8
20+ to 30	1/2
Over 30	3/4

B-2. The removal of gates and risers shall not produce depressions which are more than 1/8" below the casting design surface; except that for castings having risers greater than 20" maximum dimension the depression shall not be more than 1/4" below the casting design surface.

B-3. The responsibility for furnishing castings that can be laid out and machined to the finished dimensions, within the tolerances given and without further straightening by the customer, shall rest with the foundry only if both a pattern and drawings are furnished. If the foundry is furnished a pattern without accompanying drawings, the foundry fulfills its responsibility as to casting dimensions by furnishing castings which are true to the pattern.

B-4. Castings shall be within a weight limit of +5 or −3 per cent.

C—Heat Treatment

C-1. Pyrometric equipment shall be used to enable the heat-treating procedures given in C2 to C4 to be satisfactor-

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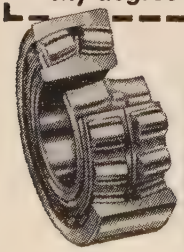

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ily carried out. Pyrometric equipment shall be maintained in accurate condition at all times. Checks for accuracy shall be made at least once each 30 days.

C-2. Castings shall be heat-treated by one of the following three methods at the option of the manufacturer:

(a) Full Annealing

(b) Normalizing

(c) Normalizing and tempering (stress relieving)

C-3. *Heating.* Regardless of the heat treatment employed, the castings shall be uniformly heated to a temperature above the transformation temperature and shall be held at this temperature for a sufficient length of time to refine the grain. The temperature difference between the hottest and coolest part of the charge during the holding period shall not be greater than 75°F. (See Note A)

C-4. *Cooling.* The castings shall be cooled as follows:

(a) Full Annealing. Castings shall be cooled slowly in a closed furnace from the annealing temperature. When the temperature of the furnace has fallen to 1000 degrees the castings may be removed and cooled in air.

(b) Normalizing. The castings shall be removed from the furnace and cooled in air.

(c) Tempering (stress relieving). Castings shall be heated to a temperature below the lower critical and held at this temperature for not less than one hour. After the heating period the castings may be furnace cooled or removed from the furnace and cooled in air.

D—Repair of Defects

D-1. The welding of steel castings, whether for repair of defects or addition of other structures, is permitted at any point in their processing provided the following conditions are complied with:

(a) The defect shall be thoroughly and completely removed.

(b) The area to be welded shall be clean and free from sand and scale or other extraneous material.

(c) The welding shall be performed in accordance with the procedures stipulated in the SFSA Recommended Practice for the Welding of Steel Castings.

NOTE A: For information on the transformation temperature for commercial carbon steel castings see Fig. 283, page 209 in the Steel Castings Handbook, 1950 Edition.

E—Methods of Sampling, Inspection and Tests

E-1. All castings shall be surface inspected for defects and surface appearance after final cleaning for shipment.

E-2. Representative castings from each order or lot shall be inspected for adherence to tolerances.

E-3. It is recommended that for castings in lots of 50 or more and, if practical, castings should be inspected by destructive or non-destructive tests to ascertain whether they are as sound as ASTM Radiographic Standards, E-71, Class 4.

E-4. One tension test shall be made from each heat in each lot. The design of such test coupons shall be the Standard ASTM Test Coupon illustrated in ASTM Tentative Methods and Definitions A370-53T (Mechanical Testing of Steel Products). If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted from the same lot. The term

"Allis-Chalmers Graduate Training Course Gave me a head start"

says GERALD SMART

Marquette University, BS—1948
and now Supervisor of Plant Engineering,
Allis-Chalmers, Norwood, Ohio, Works

"MOST MEN graduating from college don't have a clear idea of what they want to do. These individuals are helped by Allis-Chalmers Graduate Training Course to find the right job whether it be in design, sales, engineering, research or manufacturing.

"My case is a little different, however. I started the course with all my interest centered on tool design and 'in-plant' service. The reason is that I started getting vocational guidance from some very helpful Allis-Chalmers men back in 1940."

Served Apprenticeship

"At their suggestion I had gone to school part time while working full time. This not only gave me the chance to serve an apprenticeship as a tool and die maker, and earn money, but I learned what I wanted to do after graduation.

"Then came the war and service in the Navy. After the war I finished school. By the time I started on the course in 1948, I knew what I liked and seemed best fitted to do. As a result, my entire time as a GTC student was spent in the shops.

"The 18 months spent in the foundry, erection floor and machine shop have all proved valuable background for my present job.

"As supervisor of plant engineering at the Norwood Works, I am concerned with such problems as: Plant layout, material handling equipment and methods, new construction, new production methods to be used in building motors, centrifugal pumps, and *Texrope* drives. It's an extremely interesting job.

"From my experience, I'd say, whether you're a freshman or a senior it will pay you to talk to an Allis-Chalmers representative now. You can't start planning your future too soon. And you can't plan starting at a better place, because Allis-Chalmers builds so many different products that you'll find any type of engineering activity you could possibly want right here."

Facts You Should Know About the ALLIS-CHALMERS Graduate Training Course

1. It's well established, having been started in 1904. A large percentage of the management group are graduates of the course.

2. The course offers a maximum of 24 months' training. Length and type of training is individually planned.

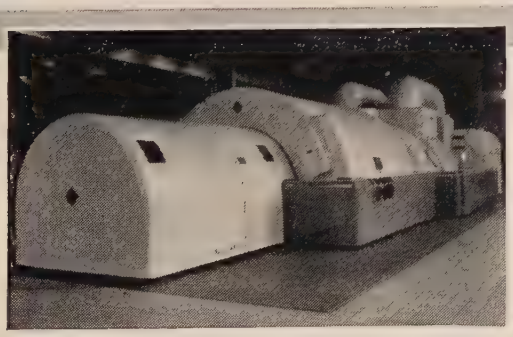
3. The graduate engineer may choose the kind of work he wants to do: design, engineering, research, production, sales, erection, service, etc.

4. He may choose the kind of power, processing, specialized equipment or industrial apparatus with which he will work, such as: steam or hydraulic, turbogenerators, circuit breakers, unit substations, transformers, motors, control pumps, kilns, coolers, rod and ball mills, crushers, vibrating screens, rectifiers, induction and dielectric heaters, grain mills, sifters, etc.

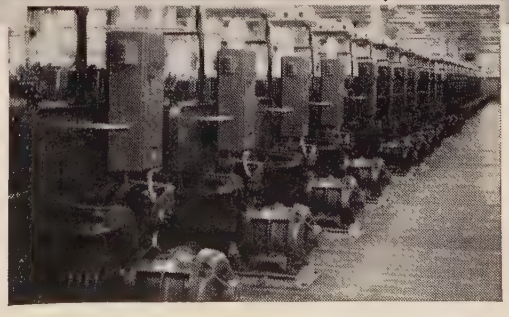
5. He will have individual attention and guidance of experienced, helpful superiors in working out his training program.

6. The program has as its objective the right job for the right man. As he gets experience in different training locations he can alter his course of training to match changing interests.

For information watch for the Allis-Chalmers representative visiting your campus, or call an Allis-Chalmers district office, or write Graduate Training Section, Allis-Chalmers, Milwaukee 1, Wisc.



Steam turbines, condensers, transformers, switchgear, regulators are built for electric power industry.



Motors, control, *Texrope* V-belt drives—all by Allis-Chalmers are used throughout industry.

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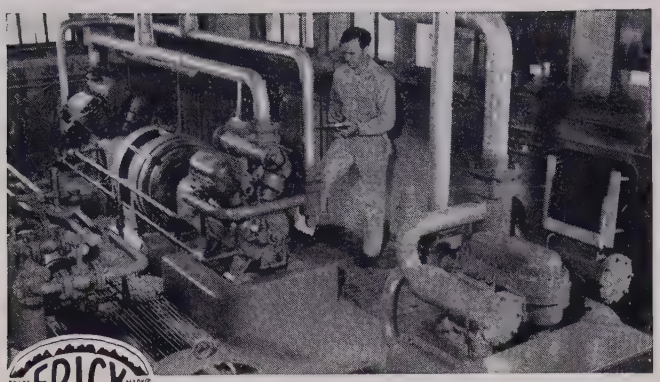

FRICK

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"lot" shall be considered as all castings in a heat subjected to the same heat-treating procedure. After meeting acceptance tests for ten consecutive heats used for making castings of any one grade, the manufacturer may assemble the castings from succeeding melts in groups of five heats each. The castings in each group shall be accepted on the basis of one test specimen taken from every fifth heat, provided that the chemical anlysis of all the heats in the group falls within the range established by the first ten consecutive acceptable heats and all subsequent heats that are physically tested and found acceptable. If this test fails, the heat may be requalified by using another specimen, and the four other heats in the group shall be tested individually. The same heat-treating procedure used for the first ten consecutive heats shall be used for all subsequent heats. This procedure shall be established for each grade separately.

E-5. In cases where more than one heat is poured into a ladle (teeming of several heats), the heat shall be deemed to be the ladle from which the castings are finally poured.

E-6. The coupon, for mechanical test specimens, shall be poured with metal which has received deoxidation treatment identical to that metal from which the castings are poured.

E-7. One tension-test specimen from each lot (as qualified in paragraph E-4) shall be tested and shall meet the minimum properties noted in Table I.

E-8. When any test specimen shows defective machining or obvious lack of continuity of metal, it may be discarded and replaced by another specimen from the same lot.

E-9. In the event two test specimens from any lot fail to meet the minimum requirement noted in Table I, the castings may be re-heat-treated as often as desired with a coupon from the same heat.

E-10. Chemical analysis of each heat shall be made to determine acceptance as noted in Table I. Drillings for chemical analysis may be taken from broken test specimens, castings poured in the heat or from a separate block representing the melt. (See Note B)

NOTE B: The alloying elements Mo, Cu, Ni and Cr need not be determined by analysis on every heat, but it is recommended that they be determined at intervals.

TABLE I

Chemical and Mechanical Property Requirements

Chemical Composition—Maximum percent								
C*	Mn*	Si†	P	S	Mo**	Cu**	Ni**	Cr**
.33	.70	.80	.06	.06	.20	.50	.50	.25

*For each reduction of .01 percent carbon under the maximum specified, an increase of .04 percent manganese above the maximum specified will be permitted.

†Minimum silicon permitted is .25 percent.

**Total content of these unspecified elements shall not exceed 1.00 percent.

MECHANICAL PROPERTIES***

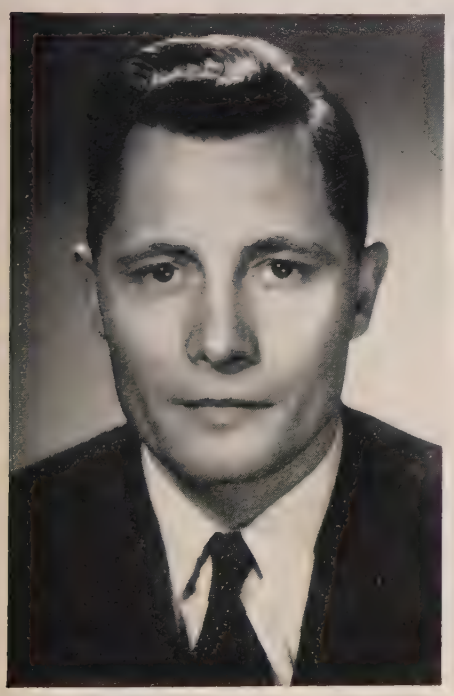
Tensile Strength Minimum psi	Minimum psi Yield Point	Elongation in 2 inches % Minimum	Reduction in area % Minimum
60,000	30,000	24	35

***Mechanical properties shall be determined on the standard 0.505 inch diameter tensile test bar, either with or without threaded ends.

by Harvey Endler, Eng. Phy. '56 and Donnie Snedeker, E. E. '58

DR. E. C. JORDAN

Dr. Jordan, the recently appointed head of the Electrical Engineering Department here at the University of Illinois, attributes his career in electrical engineering to a boyhood interest in radio. While working in a drugstore in



DR. JORDAN

Edmonton, Alberta, Canada with aspirations of becoming a pharmacist, Dr. Jordan heard of a job opening at CKUA, the radio station of the University of Alberta, and his deep interest in his hobby led him to forsake pharmacy and take the job as a technician for the studio. He began taking selected courses at the University of Alberta, and soon discovered that he was able to take a full engineering program in addition to working as a control operator for the station.

In 1933 he built for CKUA the first studio control board with automatic gain control, which was, incidentally, the topic of his Master's Thesis. He received his B.Sc. and M.Sc. in 1934 and 1936 respectively, from the University of Alberta. He then taught at Worchester Polytechnic Institute and Ohio State before coming to Illinois in 1945 as an associate professor of electrical engineering. In 1947 he became a professor and in July of this year was appointed head of the department. In addition to heading the department Dr. Jordan teaches the first graduate level course in electromagnetic theory, using his own book, "Electromagnetic Waves and Radiating Systems."

Dr. Jordan has carried on extensive research on antennas, a subject in which he first became interested while teaching at Ohio State. A great deal of this research was carried on during the war under contract of the Office of Scientific Research and Development, and dealt mainly with antennas for high speed aircraft.

Dr. Jordan is married and has three boys, ages six, nine, and ten and a half, whose only interest in electrical engineering thus far has been in turning the TV set on and off. However, to anyone else who is considering entering the profession, Dr. Jordan recommends that they have a liking for mathematics and physics. To those already in engineering he gives the words of advice that "what you get out is directlfy proportional to what you put into your work," and that the best system is "to work like a dog but have fun doing it." He is a firm believer in the importance of extracurricular activities for engineering students.

JIM SMITH

Who says Agricultural Engineers never get off the farm? Here's one who's really been around —

A native of Pennsylvania, Jim graduated from high school in Elmira Heights, New York, where he played football, basketball, and served as president of his class. Cornell University came next for three semesters before he enlisted in the Army. After deciding that a private's life was not for him, Jim took and passed the test for West Point preparatory school. He studied for one year and in July, 1952, entered West Point. Upon completing freshman year, Jim resigned his appointment and came here to the University of Illinois

JIM SMITH

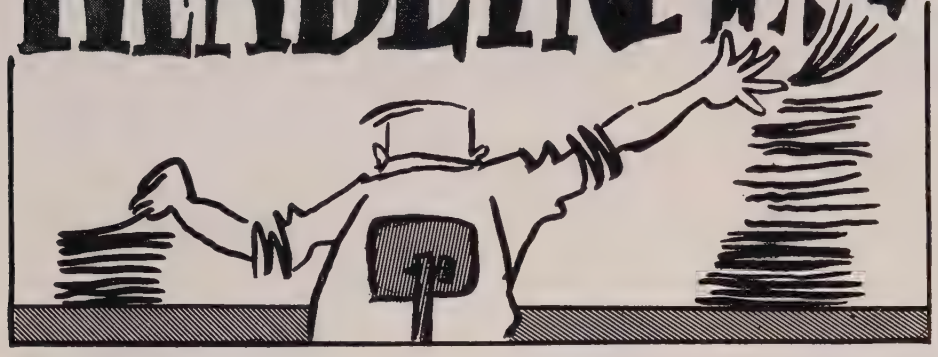
to study Agricultural Engineering.

One of those pretty Illinois girls had her trap laid for him and last August, she became Mrs. Carolyn Smith. Jim seems to like being trapped, though!

Besides serving as Business Manager of the Technograph this year, Jim is a member of the Engineering Council and president of the Illinois Student Branch of the American Society of Agricultural Engineers. All this and studies, too, but he still tries to find a little time for hunting, fishing, and playing golf.

After receiving his sheepskin in 1956, Jim hopes to remain on at the University for graduate work or go into tractor test and design.

SKIMMING INDUSTRIAL HEADLINES



edited by Larry Kiefling, M. E. '56

Super Sabre

The Air Force Tactical Air Command today received its first F-100 Super Sabres and soon will have squadrons capable of fighting at speeds faster than sound.

Ten minutes after accepting delivery of his unit's first F-100 at North American Aviation's Los Angeles plant, Lt. Colonel Maurice G. Long, commander of the 436th Day Fighter Squadron, oashed across George AFB, 75 miles away.

"I barely retracted my landing gear before it was time to let down at George," the dark-haired veteran fighter pilot declared. "This faster than sound flight is really something."

J. S. Smithson, vice president of manufacturing at North American, pointed out that the F-100 has been on or ahead of schedule since delivery of the first supersonic fighter to the Air Research and Development Command last October. The prototype of the Super Sabre was first flown on May 25, 1953. Five months later it roared across a 15 kilometer course near the Salton Sea at an average speed of 755.149 miles an hour to set a new world's speed record.

The Air Force recently announced that a new order of $100 million has been placed for a second source of production of the F-100 at North American's Columbus, Ohio, plant.

The F-100 has been in production at Los Angeles since mid-1953 and will continue to come off assembly lines at the West Coast plant.

The 479th Fighter Wing at George will be the first operational unit to be equipped with the F-100. The new supersonic fighter will replace North American F-86F Sabre Jets which won fame in Korea by shooting down Russian-built MIGS at a rate of 13.8 to 1. The F-100 can be modified as a fighter bomber and the Air Force has announced it is capable of carrying an A-bomb.

An extensive flight testing program on the F-100 has been conducted at Edwards AFB by Air Research and Development Command and company test pilots. The Air Training Command, Air Proving Command and Air Materiel Command also have test flown the new fighter.

The F-100 incorporates a razor thin, 45 degree sweptwing and tail and was especially designed for high speed flight. The new, heat-resisting metal, titanium, is used extensively throughout the plane. It is powered by the powerful Pratt and Whitney J-57 turbojet with afterburner rated in the "10,000 pound thrust" class.

Maintenance crews have reported the F-100 much easier to work on because of quick access to radio, radar, electrical and other accessory equipment.

Ready for delivery to the Air Force are these F-100 Super Sabre Jets at a North American Aviation's plant. The Air Force has just placed a $100 million order for more of these planes.

Heat-Sensing Cell

Little slips of glass coated with lead sulfide that can give 10,000 times as much sensitivity to certain infrared rays as previous laboratory instruments have now been put on sale to science and industry.

Known as Kodak Ektron Detectors, the new photoconductive cells were first unveiled at the convention of the American Society for Testing Materials. The extreme infrared sensitivity of the cells, coupled with their simpilicity and adaptability to manufacture in any size or shape, opens wide new possibilities to engineers in developing new devices based on the ability to detect warm ob-

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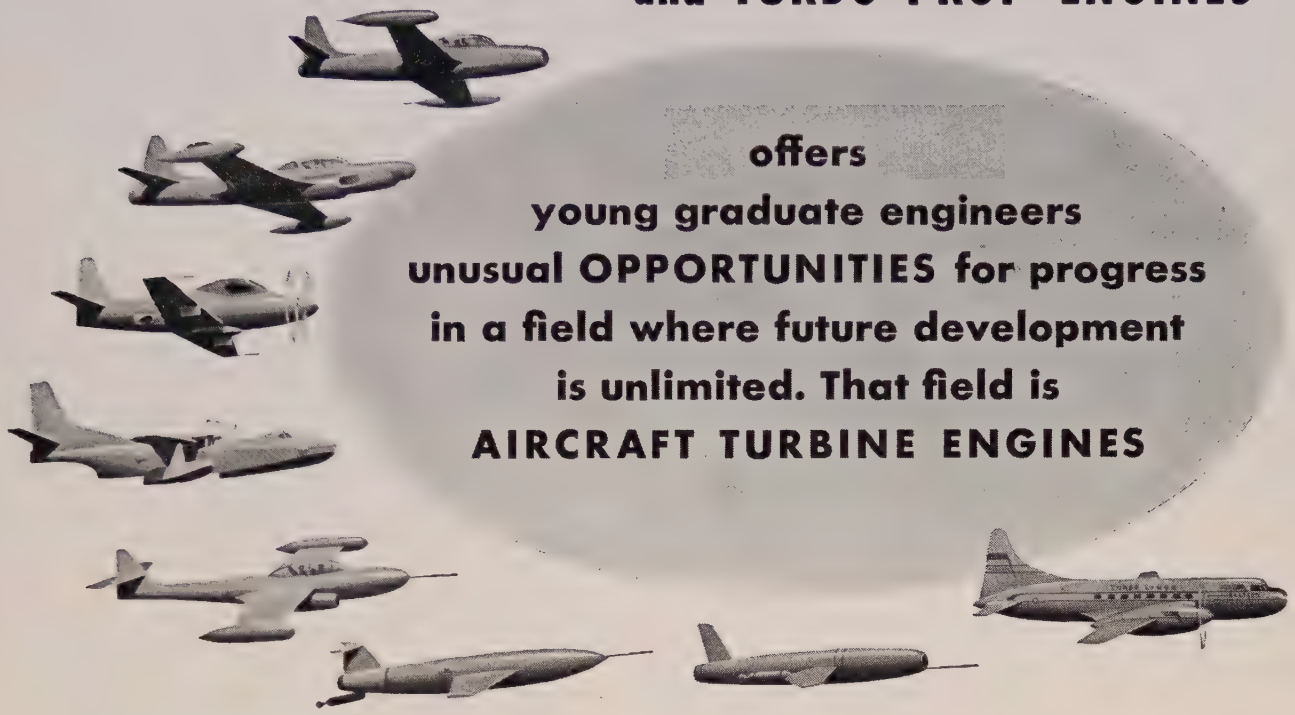

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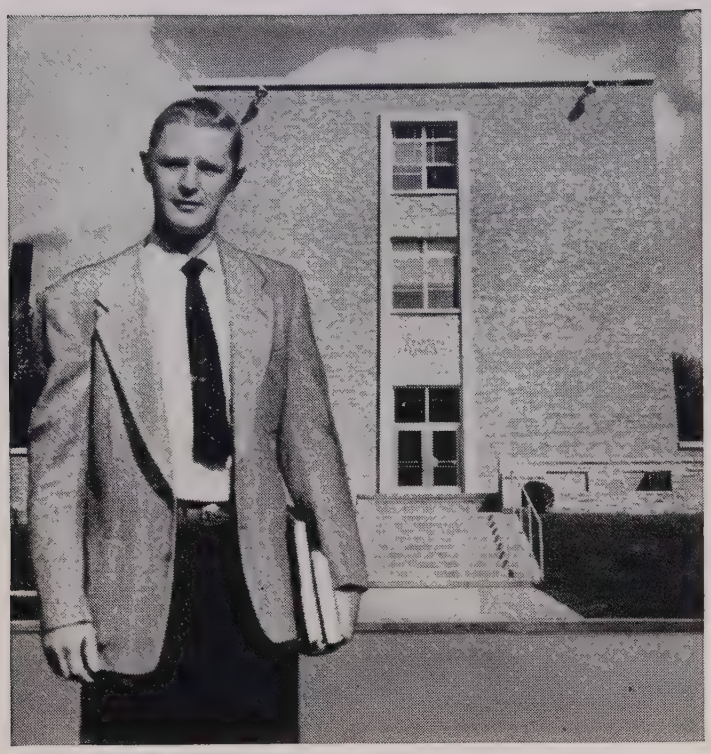

Delbert N. De Young received a B.S. in Chem. Eng. from the University of Wisconsin last June. Now he is working for an M.S. degree. By asking questions, he's learned that many excellent industrial opportunities are passed over because they're not understood by the average undergraduate.

Del De Young wants to know:

What sort of work is involved in technical sales at Du Pont?

Clarence D. Bell, B.S., Chem. Eng., Univ. of Pitts. (1937), joined Du Pont as a chemical engineer immediately after graduation. He began in the research group of the Ammonia Department, progressed steadily through assignments on nylon and a number of other products. Today he is an Assistant Director of Sales in the Polychemicals Department.

Clarence "Ding" Bell answers:

Well, if I said "All sorts," it might sound a bit vague to you, Del, but it would be very close to the truth. That's because technical sales work at Du Pont—bearing in mind the great diversity of products we have—is broader in scope than a lot of other technical assignments, and requires additional talents.

Let's suppose that one of Du Pont's customers is having technical difficulties—needs help in adapting "Teflon" to a specific gasketing application, for example. When our sales representative calls, he naturally must carry with him the engineering knowledge that's the basis for sound technical advice—data on flexural fatigue, chemical passivity, and deformation under load. The customer is receptive. He wants to make a better product, increase his sales, reduce costs—or do all three. Naturally, he's looking for reliable technical advice and intelligent actions that apply to his specific conditions. With the cooperation of the customer and help from our own research people, when necessary, the problem will sooner or later be "licked."

We have found, though, that if a technical service man is going to be *truly* effective in such a situation, he must possess certain *human* qualities in addition to his technical ability. That is, he must really *like* people and be sincerely interested in helping them solve their problems. He must—in every sense of the word—be an "ambassador" who can handle human relationships smoothly and effectively.

Take the depth suggested by this simple example, Del, and multiply it by a breadth representing all the challenging problems you'll run into with Du Pont's diversity of products. If your slide rule isn't too far out of alignment, the resulting area should give you some idea of what I meant by "all sorts" of work.

Let me emphasize one more point. The importance of effective sales work is fully understood and appreciated at Du Pont! In the past, sales work has been one of the active roads to top management jobs. There is every reason to believe that this will continue in the future.

DU PONT
REG. U. S. PAT OFF.

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...THROUGH CHEMISTRY

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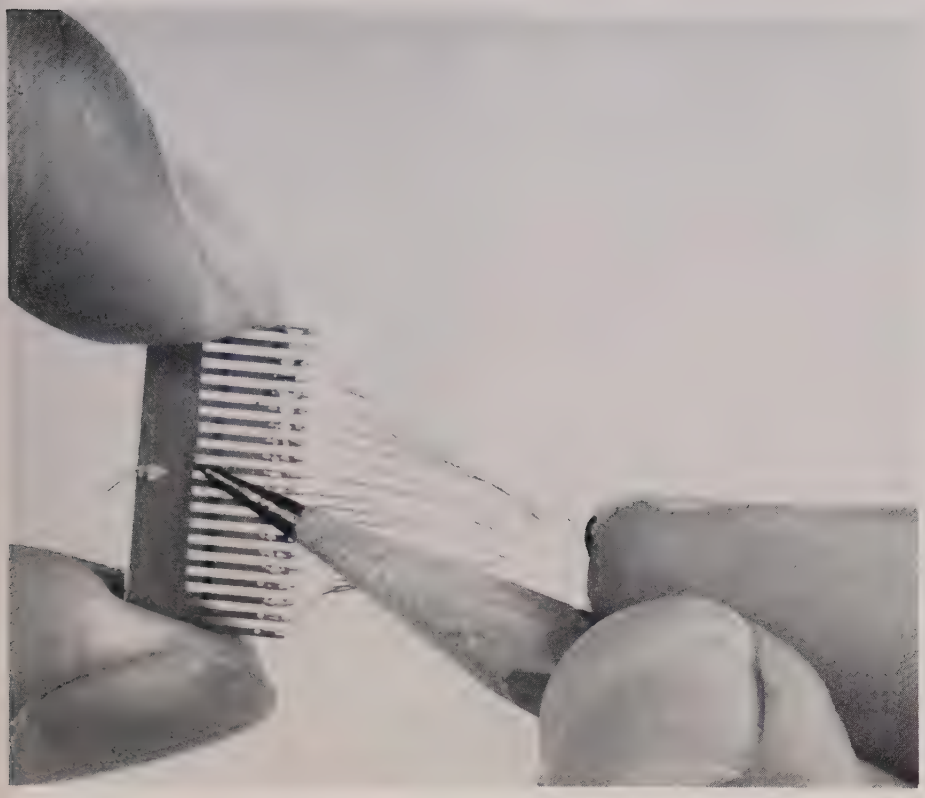
Are you inclined toward sales work? There are four main types of sales activity in the Du Pont Company—technical sales service, sales development, market research and direct selling. Information on sales, and many other facts about working with Du Pont, are given in "The Du Pont Company and the College Graduate." Write for your copy of this free 36-page booklet to E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Building, Wilmington, Delaware.



Twenty light-and-heat sensitive cells are contained on a bit of glass ¾-inch long. The tiny black specks lying under the pencil point are the cells themselves.

jects without physical contact and over long distances.

Announcement of the availability of the Ektron Detectors culminates a decade of research by a team of scientists under Dr. G. W. Hammar. Though the cell reaches its peak of sensitivity in the invisible heat rays of the near-infrared, it is highly sensitive to all colors of visible light and on into the ultraviolet.

As a demonstration of the new cell, Kodak representatives have been exhibiting a small box that emitted squeals whenever the Ektron Detector on it "saw" the bit of hot ash on the end of a cigarette. It also squealed loudly when a flashlight was pointed at it with battery cells so weak that the lamp filament scarcely glowed.

In addition to its possibilities for heat detection devices and for the replacement of present types of "electric eyes" in rough-service applications, the Kodak company also sees a strong potential for Ektron Detectors in automatic control of chemical processing plant operations and in complex electrical equipment where mechanical switching devices are too bulky, impractical, or insufficiently reliable.

In the chemical plant applications, the cells could automatically monitor the exact composition of fluids flowing through pipes and process vessels on the basis of the characteristic infrared "color" of the various components. Water and gasoline, for example, are both colorless liquids to the human eye but look entirely different to a sensitive infrared detector. Very fine differences between chemicals can be detected in this way.

In the switch applications, say the Kodak engineers, the Ektron Detector permits a beam of light to eliminate a moving part. The "light," they point out, can come from a lamp operated so far below the rated current that the glow is invisible and lamp life is therefore unlimited. Ektron Detectors were shown at the convention June 14 in the form of multiple arrays of as many as 20 pinpoint specks of lead sulfide on less than an inch of glass. These are intended to operate complex combinations of electrical circuits in response to projected patterns of light or heat radiation.

Carilloy

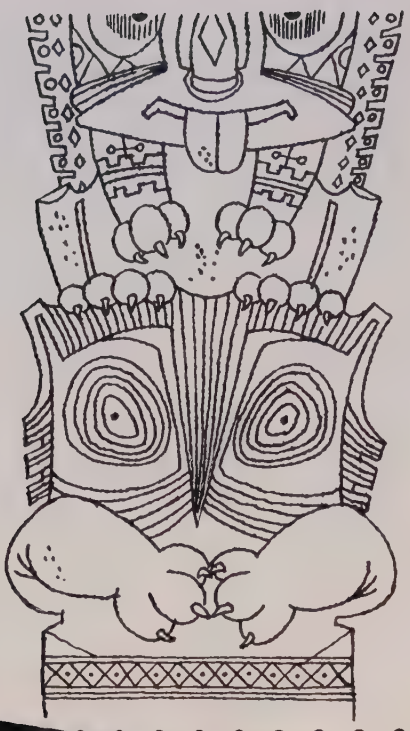
Coated with ice at 45 degrees below zero, four large closed pressure tanks of a new kind of steel were put through dramatic burst and impact test paces under a hot summer sun.

The vessels were made of a new quenched and tempered steel known as "Carilloy T-1." This new material is the product of United States Steel Corporation's Research Laboratory.

The tests were staged in an open area adjoining the plant of Chicago Bridge and Iron Company. Engineers and research experts of both companies took part in the series of tests before an audience of government and technical code authorities, representatives of the Atomic Energy Commission, army and navy officers, as well as the heads of military and civilian aeronautical groups.

"Operation T-1," as the test series was called, ticked off with the precision

Geyser of icy calcium chloride brine rises as big steel tank, frozen at 45 degrees below zero, is burst from internal pressure of 2,850 pounds per square inch.



WE WANT MEN WHO HAVE AN EYE ON THE TOP OF THE TOTEM POLE!

NATURALLY, the reason for hiring any man at Columbia-Southern® is that we believe he is qualified for one of a variety of opportunities the Corporation offers. We want men for whom the first job is merely a starting point. We expect Columbia-Southern to continue growing and we want men who can not only grow with the company, but who can eventually contribute to the growth.

Ultimate advancement at Columbia-Southern does not depend on any particular type of technical training. Because Columbia-Southern's operations are primarily centered around chemical production and research, more chemists and chemical engineers seek employment than people with other kinds of training; more are hired and it is to be expected that more hold top executive positions; but the number in these top positions is not out of proportion to the whole.

Of the top 42 positions in the Columbia-Southern organization, for example, 24 are college graduates who majored in chemical engineering or chemistry. The other 18 are from fields as varied as civil engineering, forestry, mechanical engineering and business administration.

We believe Columbia-Southern is a good place to work and that it abounds in opportunity. Many of the graduates who have joined Columbia-Southern in recent years said they did so only after scouring the field. And their feeling is unanimous today that they made a wise choice.

If you have the urge to get ahead, we want you to look into our organization because one thing is certain: Columbia-Southern is going places. C'mon along.

For further information, write now, Dept. P at our Pittsburgh address or any of the plants.

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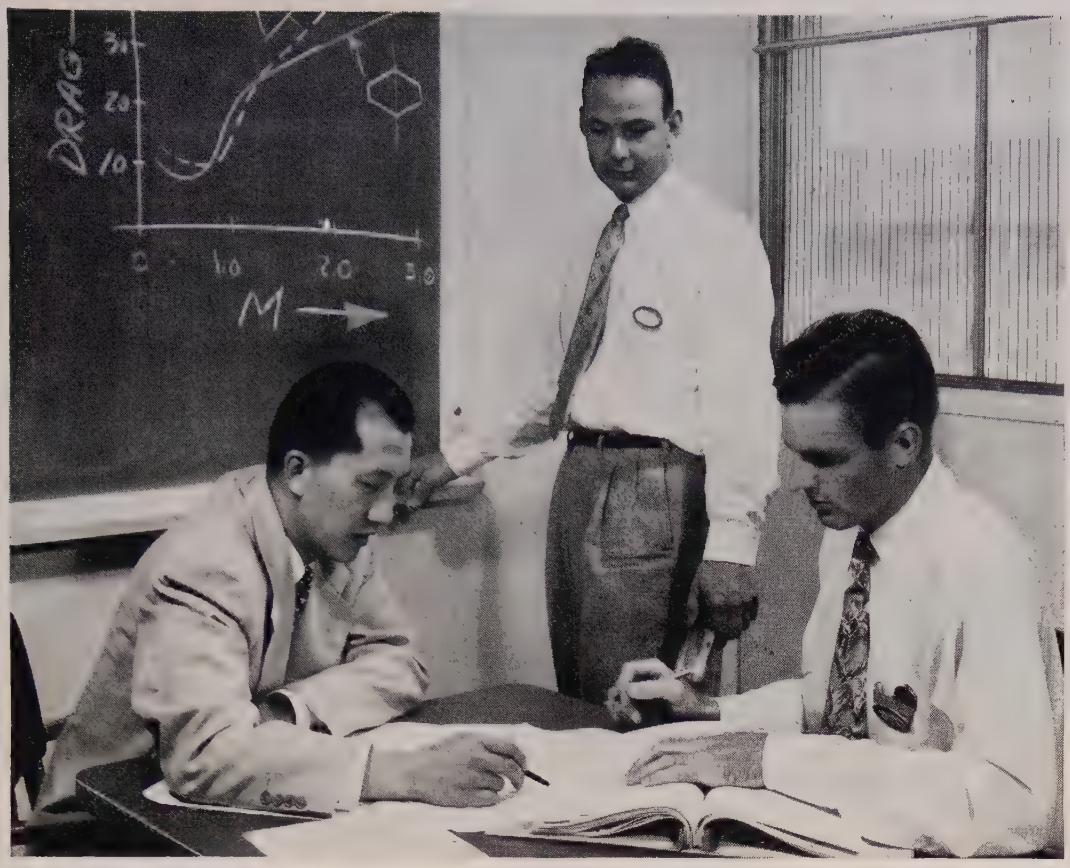


Jim Hong, *Aerodynamics Division head, discusses results of high-speed wind tunnel research on drag of straight and delta wing plan forms with Richard Heppe, Aerodynamics Department head (standing), and Aerodynamicist Ronald Richmond (seated right).*

Lockheed Expands Aerodynamics Staff

With five prototypes already in or near flight test, Lockheed's Aerodynamics Division is expanding its staff to handle greatly increased research and development on future aircraft in commercial and military fields.

The five prototypes, which show the breadth and versatility of Lockheed engineering, are: The F-104 supersonic superiority fighter; XFV-1 vertical rising fighter; C-130 U.S.A.F. turbo-prop cargo transport; R7V-2 U.S.N. turbo-prop Super Constellation transport; and an advanced jet trainer of the T-33 type.

New projects now in motion are even more diversified and offer career-minded Aerodynamics Engineers and Aerodynamicists unusual opportunity to: Create supersonic inlet designs for flight at extremely high altitude; match human pilots with rapid oscillations of supersonic aircraft at low altitude; develop boundary layer control systems for safe take-off and landing of fighters and transports; remove aileron reversal and tail flutter problems incurred in high speed flight through analysis and design; participate in determining configurations of turbo-prop and jet transports and advanced fighters, interceptors and bombers.

Career Positions at Lockheed

Lockheed's expanding development program has created a number of positions for Aerodynamics Engineers and Aerodynamicists to perform advanced work.

In addition Lockheed has positions open for Electronics Engineers, Thermodynamicists, Flight Test Analysis Engineers and Stress and Structures Engineers to perform advanced studies on such diverse projects as: Applications of nuclear energy to aircraft, turbo-prop and jet transports, bombers, trainers, supersonic fighters with speeds far surpassing those of present-day planes, and a wide range of classified activities.

LOCKHEED
AIRCRAFT CORPORATION
BURBANK **CALIFORNIA**

Program for Advanced Study — To encourage members of its engineering staff in study leading to advanced degrees, Lockheed reimburses 50% of the tuition fee upon successful completion of each course relating to the engineer's field at the University of Southern California and University of California at Los Angeles. Both universities offer a wide night school curriculum in science and engineering.

of a military maneuver, but behind the scenes long hours of hard work were required to bring the steel of the tanks down to the low temperature required. They were cooled by pumping into them hundreds of gallons of calcium chloride brine chilled by dry ice.

Two seperate test methods—burst tests and drop impact tests—were used to demonstrate the strength and toughness of the steel. Two burst tests were made on alternate days to determine how much internal pressure the tanks could withstand before they burst. In the drop tests a new method of testing full-scale vessels was used. A 26,700-pound steel weight was let fall upon the tanks from heights of 52, 73 and 101 feet to show the toughness of the steel at low temperatures. Internal pressure in the drop tests was 1,875 pounds were square inch.

Outwardly, when ready for the tests the four tanks appeared identical—20 feet long, including their hemispherical ends, and 48 inches in diameter, made from steel plates ½-inch thick, crusted with white frost, but the two tanks tested the first day were not "stress relieved," that is, they were in the natural condition, as welded. Those of the second day's tests had been "stress relieved" or given a special heat treatment following their fabrication so that internal stresses caused by the fabrication and welding were minimized. The objective was to compare how both kinds of tanks would react to the same tests.

Results of the tests performed on the four tanks were as follows:

1. Burst test non-stress relieved vessel at 45 degrees below zero, 2850 pounds per square inch internal pressure at moment of burst.

2. Drop test non-stress relieved vessel at 45 degrees below zero, 26,700-pound weight dropped from 101 feet caused break.

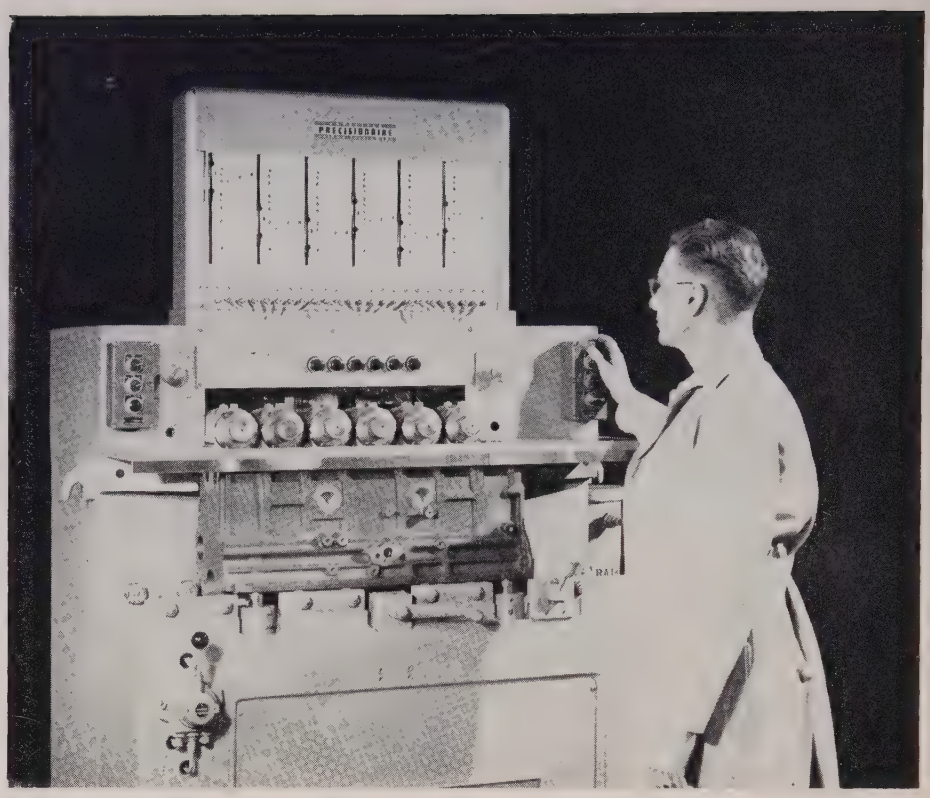
3. First test on stress relieved vessel at 45 degrees below zero, 2850 pounds per square inch internal pressure at moment of burst.

4. Drop test on stress relieved vessel at 45 degrees below zero, 26,700-pound weight dropped from 101 feet caused break.

At intervals throughout the test periods girth measurements of the tanks were made and recorded to show swelling and deformation.

Results of the burst and drop tests were spectacular. The steel showed tremendous toughness even at the very low test temperature. Yellow calcium chloride brine gushed like a geyser from a hole burst in the tank.

When the drop tests were completed the tanks had amply demonstrated their ability to withstand tremendous shock.



This model of an automotive cylinder bore gaging and classifying machine is the latest addition to the automotive industry with a rated capacity of two engine blocks per minute.

Bore Gaging Machine

Two engine blocks per minute! That's the rated capacity at 100% efficiency of the latest model automotive cylinder bore gaging and classifying machine designed and manufactured by the Sheffield Corporation.

This unique machine is used to simultaneously measure and classify bore diameters in a six cylinder engine block, to inspect out-of-roundness and taper, and to stamp the classification of each bore on the block. Bore are divided into 10 classes with a .0003 difference between each class. Classifying bore diameters in this manner permits selective matching of pistons to bores during assembly.

Six air spindles, each having two diametrically opposed air jets at four positions along its length, are motorized for rapid travel into and out of the block. They explore the bores to full depth. Each pair of air jets is connected to a glass column in the 24 column Precisionaire. The positions of the floats in the Precisionaire instantly indicates any taper, out-of-roundess, or deviation in diameter. A semi-automatic stamping device mounted above each bore marks the bore class on the block opposite each bore.

If, on occasion, a bore may taper too much or contain an obstruction restricting the upward movement of the air spindle, the cycle is stopped automatically and a red light indicates the faulty bore.

When the spindles are fully extended into the bores, a manually operated lever may be used to rotate them simultaneously 180 degrees to check out-of-roundness. Taper is indicated by comparison of four float positions for each of the six cylinder bores.

God made a machine, the machine made men,
Doctors, lawyers, priests, and then,
The devil got in and stripped the gears
An turned out the first batch of engineers.

* * *

The difference between a dress-tie and a noose is that one is worn without a collar.

* * *

Clergyman—A man who works to beat hell.

* * *

Mary: "Boy, you have to hand it to Bill when it comes to petting."
Betty: "Why, is he lazy?"

* * *

Say it with flowers, say it with sweets,
Say it with kisses, say it with eats.
Say it with jewelry, say it with drink,
But never, oh never, say it with ink.

Theory Versus Practice

by Loyal Clarke

It has long been known that theoretical developments lead eventually to new practices in industry. This was impressed on me in my college training. Experience has strengthened this conviction.

Why eventually? Why not now? Why should there so often be such a wide gap between theoretical progress and its practical application?

Shortly after graduation I made a number of suggestions to a stubborn practical engineer. Whether the suggestion was good, bad, or indifferent, his comment was always, "That's good in theory but not in practice." So one day I replied, "If something is really good in theory, it is good in practice; if the theory is right, practice is wrong; if practice is correct, the theory is wrong. A theory that does not improve practice is useless." He replied, "Then there must be a lot of rotten theories." There are indeed a lot of incorrect or misleading theories. Even a good theory can fail because of its improper usage. A proper application cannot be made unless the theory applies to plant conditions and takes economic factors into consideration.

What are the pitfalls for application of theory? Occasionally, a theory may be entirely correct. More often it is not sufficiently complete. The ideal conditions for which it was derived may differ considerably from plant conditions and therefore not apply. Still more often good theories are manhandled, i.e., improperly used. I'll have more to say about these later. First, let's talk about the most common pitfall of all.

Failure to fully consider costs has led to countless disasters.

A classic example is the story of a tung oil pressing plant built in China back in the "twenties." For centuries the Chinese coolies had been pressing tung oil by driving wedges into logs, putting seeds into the split, and then removing the wedges. A young chemical engineer reasoned, correctly, that this was a poor method of pressing—high labor and low yield. So he built a modern hydraulic pressing plant and went broke. His power, maintenance, and capital costs far exceeded the costs of Chinese coolie labor.

Yes, this was a freak condition, but the same type of thing often happens in our modern industry. The large Fischer-Tropsh plant was recently shut down at a loss of, perhaps, $75,000,000. Just a few years ago another petro-chemical plant failed and several millions of dollars were lost.

What is efficiency? Any engineer can define the mechanical efficiency of a pump. Is a pump of the highest mechanical efficiency the most efficient to install? Probably not. The management is interested in the total cost of the operation. This total cost includes operating labor, maintenance, interest or borrowed capital. Thus, in some instances a cheap pump would be chosen. In others an expensive pump would be chosen with special features such as mechanical seals or corrosion-resistant alloys. In any event the mechanical efficiency is only one of many factors.

A practical plant criterion is "the most for the least." This, in my opinion, is equally sound in theory. Acceptance of this philosophy means that power is frequently sacrificed to lower capital costs or to reduce maintenance. A particular type of efficiency is sacrificed to save money. What does this saving in money represent? It means less steel, fabrication labor and operating labor: it allows better utilization of available capital. To put this another way, the average efficiency in the use of all our country's resources can be improved by tempering the desire for particular forms of efficiencies to improve others. Cost factors, properly used, afford a reasonable measuer of the overal efficiency.

A theory may be correct but not sufficiently general to apply as we might wish. When I went to college we were given a formula for filtration rates, a useful formula that gave satisfactory results for most cases. The filtration of some solids (such as those removed from vegetable oils) completely ignored the theory. Why? The formula was based on an incompressible cake but some solids form compressible cakes. Since then, theory has been extended to include allowance for the missing factor.

Shortly after marriage I told my wife not to boil the potatoes so fast. Since water boils at 212°F the potatoes would cook equally fast if boiled slowly. She promptly demonstrated that potatoes cook faster when boiled rapidly. Agitation by rapid boiling improves the heat transfer.

It is common practice to design coolers and heaters from theoretical calculations. This acceptance is natural because the calculated rate of heat transfer is nearly always within a few per cent of that observed for new equipment. After a limited period of service, the rate may drop due to solid forming deposits on the tubes, shutting down an operation before the scheduled shutdown period. This would increase maintenance costs and upset the general maintenance shop schedules. The reduction of heat transfer by fouling is not susceptible to theoretical treatment, but empirical fouling factors have been developed from experience and acceptd by theoretically minded people. Many such factors of safety are used in equipment design and specifications.

Thus before an application of theory is attempted careful consideration of a number of factors should be made. Care should be taken that the theory is applicable to the actual conditions. Proper safety factors to cover any uncertainties should be included. Finally, an overall benefit for the ultimate objective must be shown. A better product at low cost is the most common objective.

Modern industry is complex and it is seldom that one person can evaluate all the ramifications of even his own ideas. Rather, a new idea is turned over to many people. One should welcome this review even though often the idea may receive unfair treatment. More often, the reviewers will reject the idea because it has disadvantages that were not at first evident. It may be a good idea but just a little short on economic advantage and therefore be sidetracked for more promising developments.

Unfair treatment of new ideas is indeed common—some people are downright prejudiced against new ideas other than their own. Others are too conservative and very hesitant in approving new projects even after it has been demonstrated that the project looks favorable and is a good "calculated risk" for capital investment.

How can we combat this prejudice and inertia? I think it is a hazard of our trade, something that we must live with. At least, we can do much to minimize it and can make much progress, despite the inertia, through patience and understanding.

Consider an engineer who has developed a new process and had the pleasure of seeing it operate satisfactorily and make money. Of this he should be proud. Unless he is unusually broad minded, this pride may blind him to the possibilities for improvement and to the weakness of his past work. During the course of development he probably tried many ideas that failed. He knows that a new idea represents a new gamble and unless

the expected benefits are very high indeed, he may be slow to take the gamble. When the plant is in trouble or a new process is to be installed, then the same man will show interest in new ideas. At those times of dire need, the men with good ideas have a good opportunity to secure the confidence of the hard-bitten administrators. At times like these a file of ideas is valuable. Then, too, there are very few so completely opposed to change as they first appear. Indeed no one can maintain a reputation by rejecting all progressive ideas.

So, by a reasonable balance between patience and impatience you, who are full of new ideas, can look forward to seeing many of them put into practice. You can best promote an idea if you give careful consideration to all competing theories, practical aspects, and weak points before advancing it and then listening eagerly to the comments. Careful listening may permit still further improvement. One who suggests an improvement should be as zealous in improving his own ideas as he is in changing another's. Most of all, keep plugging and don't allow any kidder or vicious plant engineer to destroy your initiative. All too often young engineers are "beat down" during their training period. They too follow only "the book" of standard practice and become just the type that they had earlier detested.

Sure I know that it is discouraging to see good ideas shoved unceremoniously into the waste basket, or to be told that your idea had been rejected five years earlier. So what? You have many years ahead, and many, many more disappointments mixed with your achievements.

As a further example, permit me to reminisce over an old friend and former boss of mine, the late Mr. J. L. Schlitt. He once said in jesting "It doesn't make any difference whether we hire a chemist, a chemical engineer, or a mechanical engineer, it still taks him five years to learn that the piping costs too much." This has all the ring of a remark of a hard-bitten practical man. Yet, he was one of the most profoundly theoretical men that I have known. He designed a complete ethylene separation unit involving the closely interlocked operation of four distillation columns, two refrigeration systems, many heat exchangers and enough instruments to fill a thirty-foot panel. This was a paper design based on somewhat incomplete data. Yet, as designed, the pilot plant made 99.8% ethylene at 85% recovery, meeting design conditions. It was difficult to put the plant in operation and its control was sensitive, so he reached into his file of calculations, already prepared for such contingencies. From about twenty possible alternates, he chose two involving minor alterations. These two changes were made and no more were ever needed. Yes, Mr. Schlitt knew his theory. He knew it so well that he appreciated all its limitations and uncertainties.

During my lifetime I have seen many reconciliations of theory and practice and many failures. I believe that the competition between the two has become less bitter and more friendly.

Probably the competition will never end; but this is good, for the reconciliation of theory and practice affords a continuing challenge to engineers of all ages.

SOLUTION:

How Many Cigarettes?

If n is the number of cigarettes which the Chesterfield man now has, then $2\frac{1}{2}n + 2\frac{1}{2}$ is the number he originally had. A check on the possible values of n shows that there must originally have been either 15 or 20 Chesterfields. If there were 20 Chesterfields, then $n = 7$ and 13 Chesterfields are smoked. This is impossible since the man who smokes Luckies smokes 2 more, doesn't smoke his total supply, and can not have more than 15. Therefore, there are 15 Chesterfields. Ten Chesterfields are smoked. This means that there must be more than 12 Luckies. The only possible number is 20.

Reilly must have either 6 or 8 cigarettes, since he must smoke half of them and more than half of the 20 are smoked. Five Kools (the only tipped cigarette in the group) are smoked. Therefore Reilly must smoke 4 of the 8 cigarettes he started with. Turner starts with 6 Kools.

Brown has 3 cigarettes due to the limited number of aces in the deck. The man who has 20 Luckies is not Perkins and therefore must be Jones. Perkins will have 15 Chesterfields. Brown does not cmoke Camels (from statement 8) and therefore must smoke Old Golds. Reilly smokes Camels.

Name	*Number*	*Brand*
Brown	3	Old Golds
Perkins	15	Chesterfields
Turner	6	Kools
Jones	20	Luckies
Reilly	8	Camels

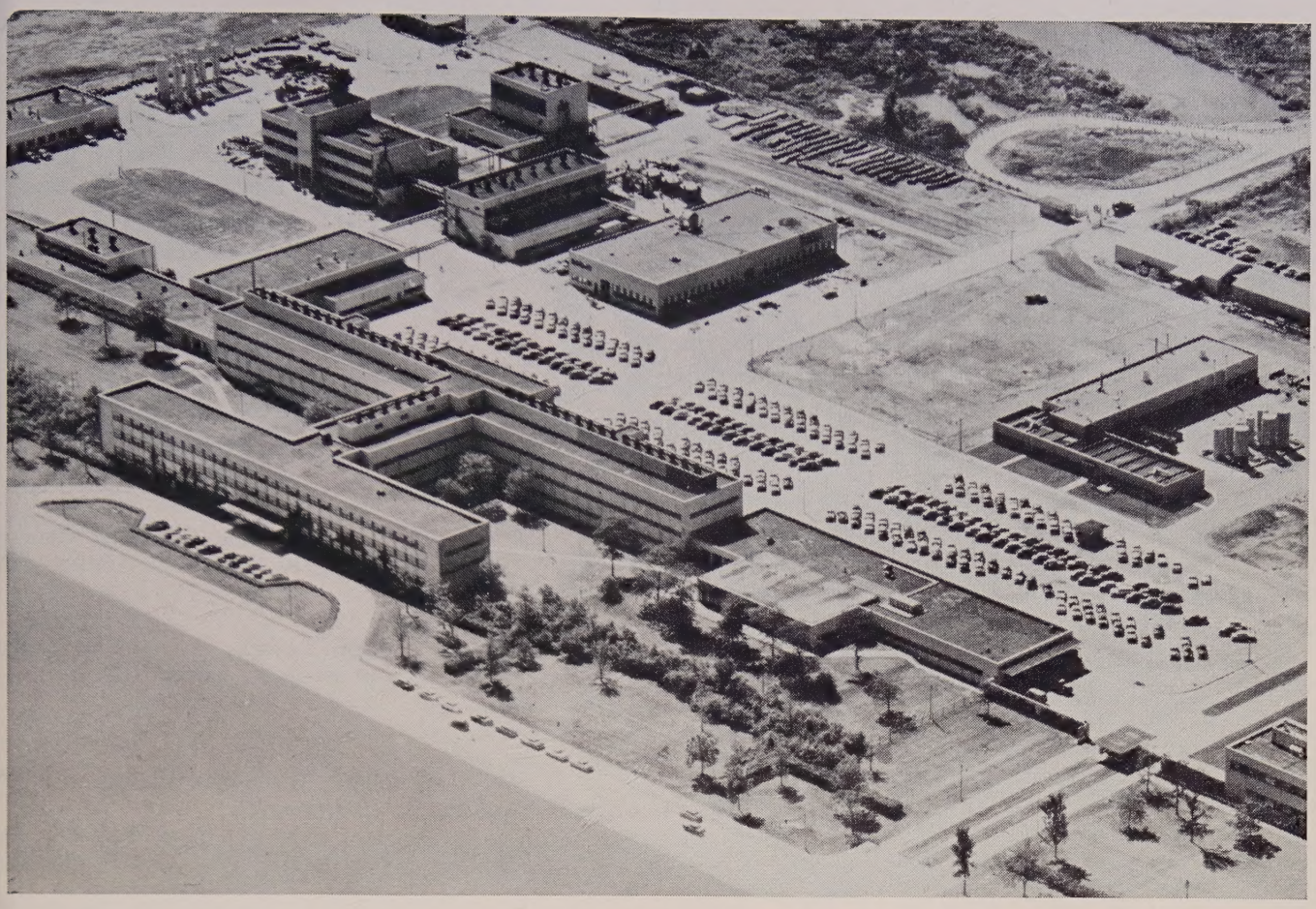
HOW A COMMON HOUSEHOLD PROBLEM INSPIRED A 19TH CENTURY TOOLMAKER

The candle that doesn't fit into the candle-holder has long been an annoyance to householders. This problem was taken up early in his career by Joseph Whitworth (1803-1887), great Manchester engineer and toolmaker—later, Sir Joseph Whitworth—who was probably the first British engineer to preach standardization as a means of obtaining interchaneability. Whitworth illustrated his thesis by pointing out a need that everyone could feel and understand—the need of standard sizes for candle-butts and candlesticks.

Whitworth later developed a system of standard gages that was widely used in British industry. In 1841, in a paper read before the Institution of Civil Engineers, he urged the adoption in Britain of a uniform system of screw threads in place of the various different pitches and dimensions then used. His thread design became known as the Whitworth Thread and was adopted both in Britain and on the continent.

In 1948, after more than thirty years of negotiation, America, Britain, and Canada agreed to merge the Whitworth Thread and the American Standard Thread into a Unified System of Screw Threads. It is the thread now used in virtually all military equipment and in most of the civilian goods produced by the three countries.

Candle-butts and candle-sticks have been standardized to some degree, but time and technology have made this problem somewhat less acute than it was when Whitworth studied it in 1830.



MOST OF THE RESEARCH WORK that led to the development of Ultraforming—a more efficient and economical refining process—took place in the Whiting research laboratories of Standard Oil, above. Extensive studies in seventeen research-scale units demonstrated the merits of cyclic regeneration.

Standard Oil scientists develop **Ultraforming--** the latest in catalytic reforming

After several years of research, Standard Oil scientists have developed a new and important refining process—Ultraforming.

The process is a better way of improving the low-octane straight-run gasoline found in crude oil. To make such gasoline suitable for present day cars, refiners must change it into an entirely different material, which gives good anti-knock performance. The change is known as reforming.

Ultraforming is the last word in catalytic reforming. It gives greater yields of higher octane gasoline than were previously possible and gets good results even with poor feed stocks. In addition, it raises the yield of hydrogen, an increasingly valuable by-product of catalytic reforming.

Ultraforming units do not have to be shut down when the catalyst begins to lose activity through use. By a new technique, an improved platinum catalyst is regenerated to maintain peak performance.

The advantages of Ultraforming over previous methods are so great that Standard Oil and its subsidiary companies are building units at four refineries. They will start operating this year. The new process, of course, is available to the petroleum industry through licensing arrangements.

At Standard Oil, young engineers and chemists work with the stimulating knowledge that they are participating in important and lasting contributions to the oil industry and to their country.

Standard Oil Company

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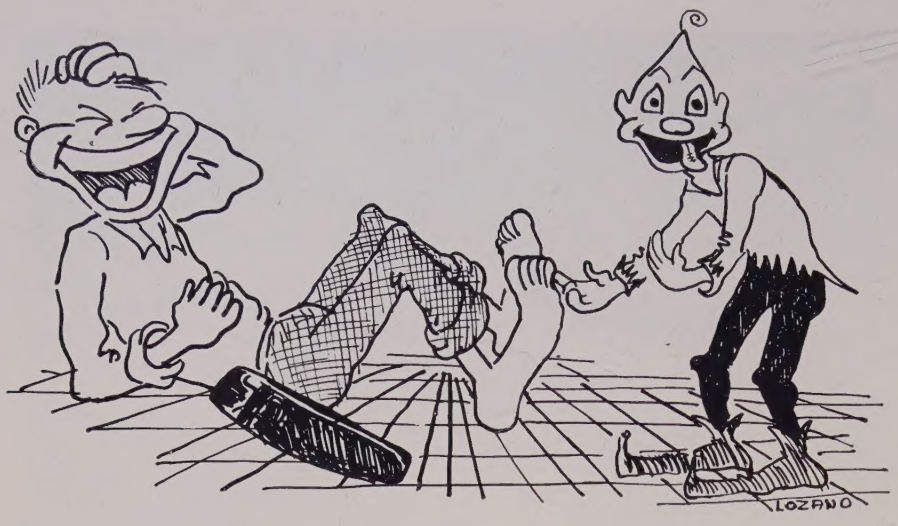

TECHNOCRACKS

THE CHAMPION

Three small boys were bragging about the prowess of their dads. The first boy said: "My dad writes out a few short lines, calls it poem, sends it away and gets ten dollars for it."

"My dad," spoke up the second lad," makes some dots on a piece of paper, calls it a song, sends it away and gets twenty-five dollars for it."

That's nothing," spoke up the third, "my father writes a sermon on a sheet of paper, gets up in the pulpit and reads it and it takes four men to bring in the money."

* * *

In the days of Queen Elizabeth 'tis said, some of the ladies of the court liked to curl up with a good book, while others preferred individual pages.

* * *

Temperance lecturer: "And in conclusion, my dear fellows, I will give you a practical demonstration of the evils of liquor.

"I have here on the table two glasses. One is filled with whiskey, the other is filled with water. I will now place an angle worm in the glass of water. See how it lives, squirms, vibrates with the very spark of life?

"Now, I place a worm in a glass of whiskey. See how it curls up, writhes in agony, and finally dies. Now young man," pointing to a student in the front row, "what moral do you get from this story?"

McKenzie: "If you don't want worms, drink whiskey."

* * *

Someone remarked the other day that a debutante is just a young tomato with lots of lettuce.

Carl: "What is the most beautiful thing in the world?"

Tom: "I say a beautiful woman is the most beautiful thing in the world."

Ben: "I claim that sleep is the most beautiful thing."

Carl: "Ah, next to a beautiful woman sleep is."

* * *

She was a secondhand-furniture dealer's daughter. That's why she wouldn't allow much on the davenport.

* * *

Then there's the little farm girl who always went out with city fellers because farm hands were too rough.

* * *

Miss: "I told him that I worshipped my figure, and he tried to embrace my religion."

* * *

Teacher: "Now, Johnny, if I lay two eggs here and three over there, how many will there be all together?"

Johnny: "Personally, I don't think you can do it."

* * *

"Let's make a date for Saturday."
"I have a date for Saturday."
"Then let's make it Sunday."
"I'm going out of town Sunday."
"How about Monday?"
"Oh, hell, I'll go Saturday."

* * *

"Now that we're engaged, darling, you're going to give me a ring, aren't you?"

"Sure kid, what's your phone number?"

Any person who claims that it is impossible to attain absolute zero hasn't taken a quiz in thermo lately.

* * *

In golf, it's distance.
In a cigarette, it's taste.
In a Crosley, it's impossible.

* * *

Engineering students are baffled by the fact that often the girls with the most streamlined shapes offer the most resistance.

* * *

If every boy in the U. S. could read every girl's mind, the gasoline consumption would drop off fifty per cent.

* * *

We heard about a wedding where the bride carried Four Roses—rather well.

* * *

Prof. Yanosik: "Give me an example of an imaginary spheroid."

M. E.: "A rooster's egg."

* * *

She: "My lawyer told me to say No to everything."

He: "Do you mind if I hold your hand?"

She: "No."

He: "Do you mind if I put my arm around you?"

She: "No."

He: "We're really going to have fun if you're on the level about this."

* * *

June (a bride) was showing her uncle over their new home.

"This is my room, Uncle. You see we have twin beds: they are so much more hygenic. That is Harry's and this is mine."

Then the uncle noticed a blue chinn clock on the mantel and remarked "What a charming clock."

"Yes," replied June, "it's a wedding present from dear Grandma."

A few weeks later the uncle received a note from June telling how the blue clock had disappeared the very afternoon he was there. Could he throw any light on the subject?

The uncle answered by return mail "Dear June, look in Harry's bed."

* * *

A fellow we know has a broken arm received for fighting for a woman's honor. It seems she wanted to keep it.

* * *

Student: "How is steel wool obtained?"

Professor: "By shearing hydraulic rams."